

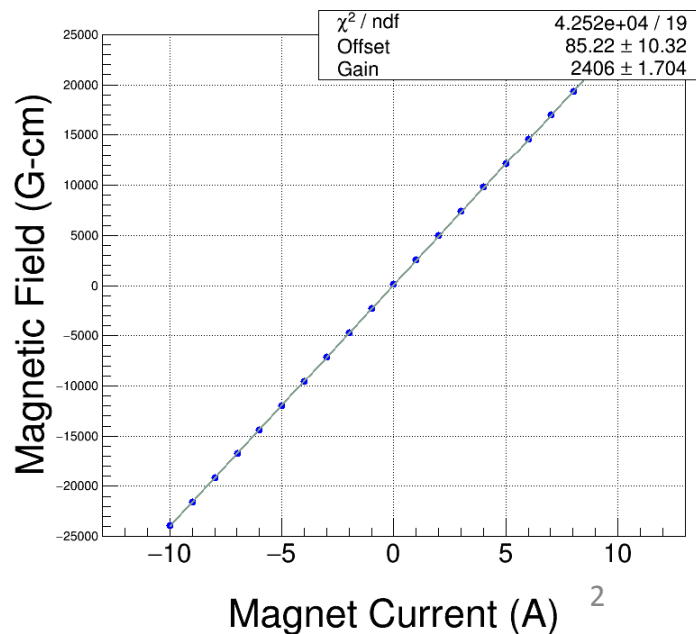
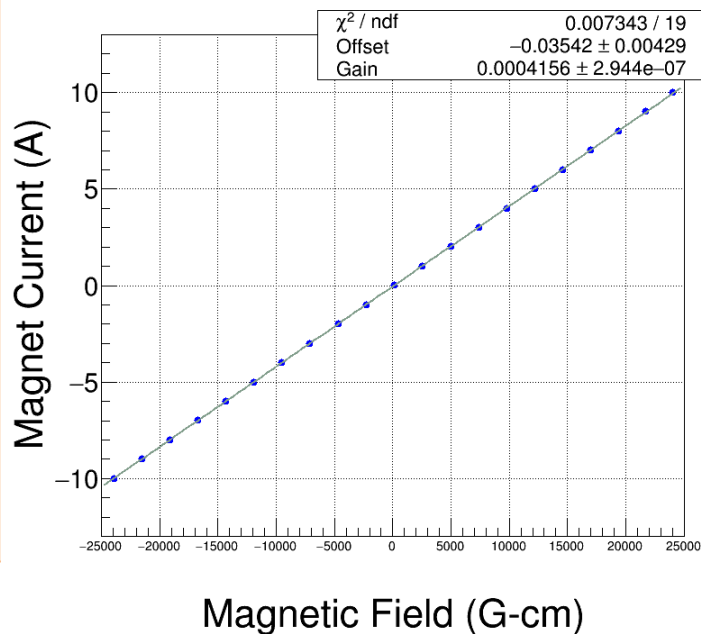
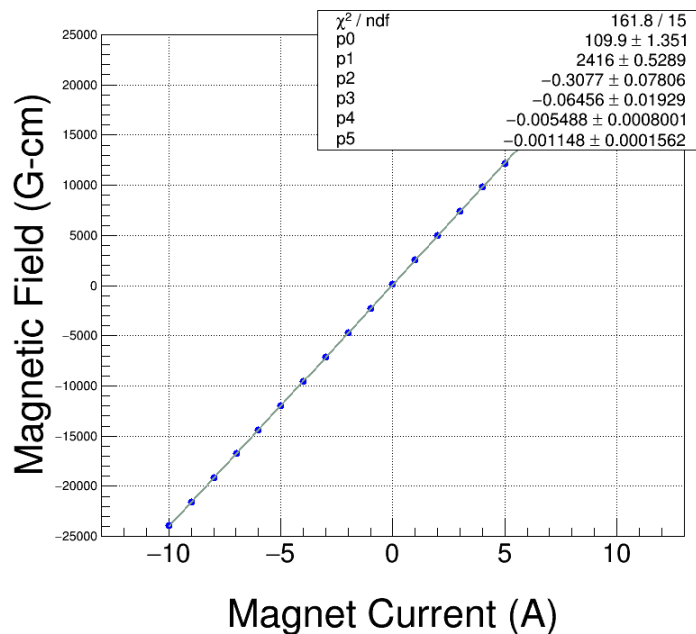
MDL0L02 Dipole Field

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



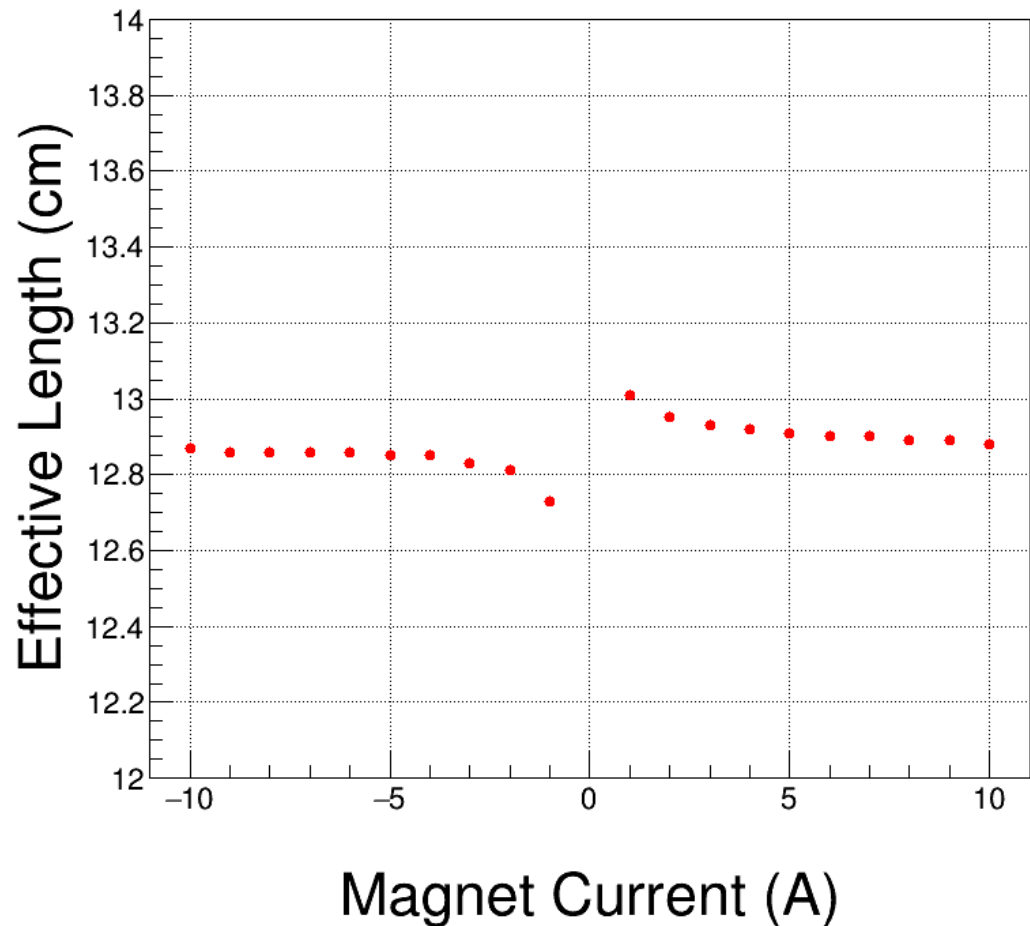
Field Map Effective Length

Meas. Date: 8/29/2014

Coil used: Hall Probe Stepper

Current (A) Eff. L (cm)

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

Trim Expert Rack:

Keep Magnet On Loop:

DTM 151:

1. CEBAF: amps

2. 2D: amps

3. 3D: amps

4. 5D: amps

Global Dipole Field: G-cm

Global Dipole Field: G-cm

Global Dipole Field: G-cm

Setpoint and Readback

setpoint: amps

readback: amps

Mismatch: ☐

Assumed Offloop: ☐

Ramping: ☐

Degauss Magnet: ☐

MPT-231 Hall Probe: 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: Gauss

Temperature: C

MPT-231 Spec:

Field Mode:

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:

DTM-151 Manual:

Dipole Survey (March 20, 2016)

On Hysteresis

$I = -0.0489 \text{ A}$

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

Hall Probe = -3.98 G^*

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

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

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)

Current Mode

1. CEBAF 0.0000 amps

2. 2D -4.8966 amps

3. 3D -1.6844 amps

4. 5D 3.7128 amps

Global Dipole Field

BDL Mode

118.720 G-cm

-11721.869 G-cm

-3962.000 G-cm

9070.000 G-cm

Trim Expert Rack

Keep Magnet On Loop

ON

OFF

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

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

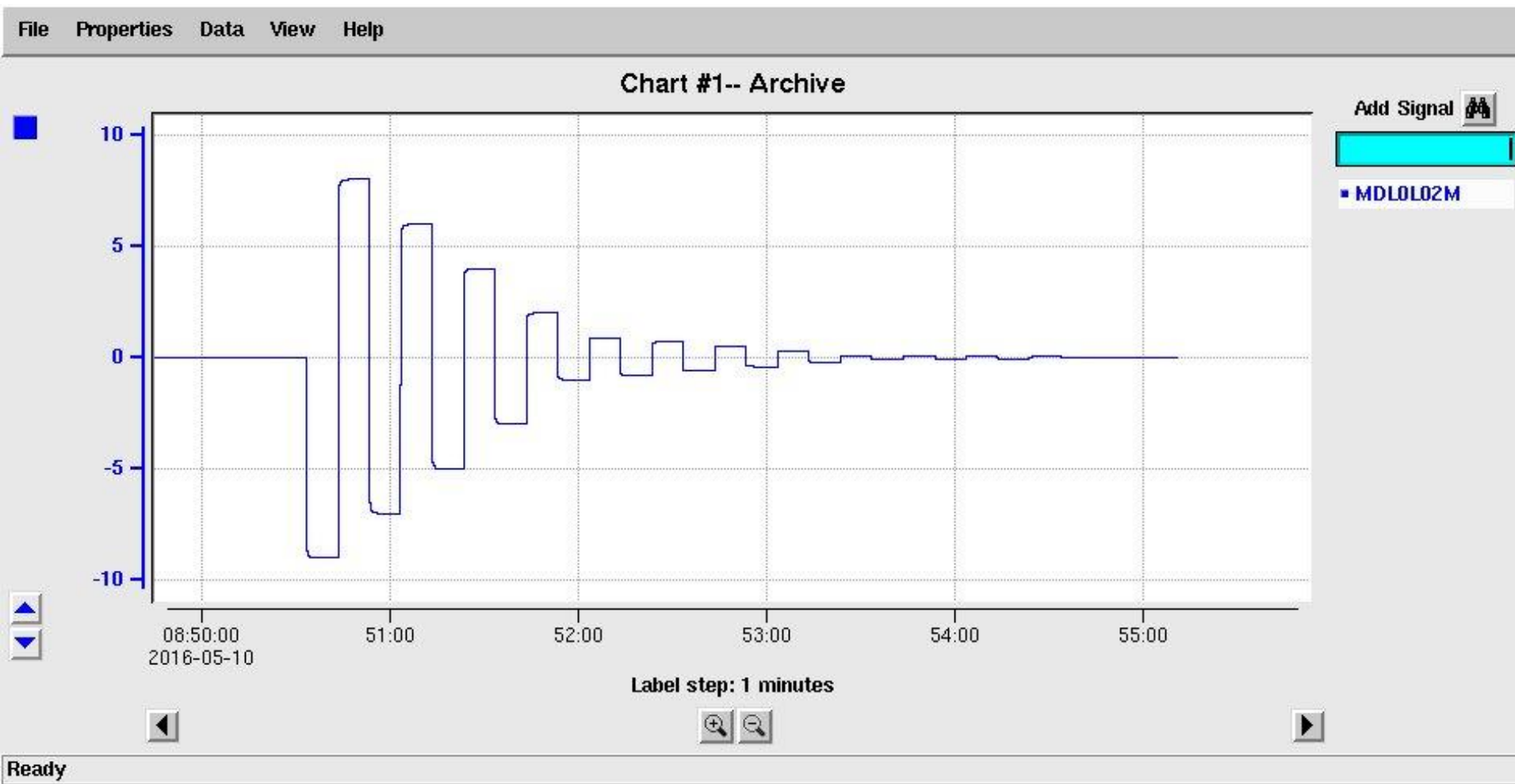
Command

Processor Reset

Factory defaults Load

DTM-151 Manual

Degaussed



Degaussed

MDL0L02 Dipole Power Supply

5 MeV Dipole (MDL0L02)

1. **CEBAF** amps

2. **2D** amps

3. **3D** amps

4. **5D** amps

Global Dipole Field

BDL Mode G-cm

BDL Mode G-cm

BDL Mode G-cm

BDL Mode G-cm

Trim Expert Rack G-cm

Keep Magnet On Loop

DTM 151

Setpoint and Readback

setpoint amps

readback amps

Mismatch amps

Assumed Offloop amps

Ramping amps

Degauss Magnet:

MPT-231 Hall Probe 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 Gauss

Temperature C

Field Mode

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

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

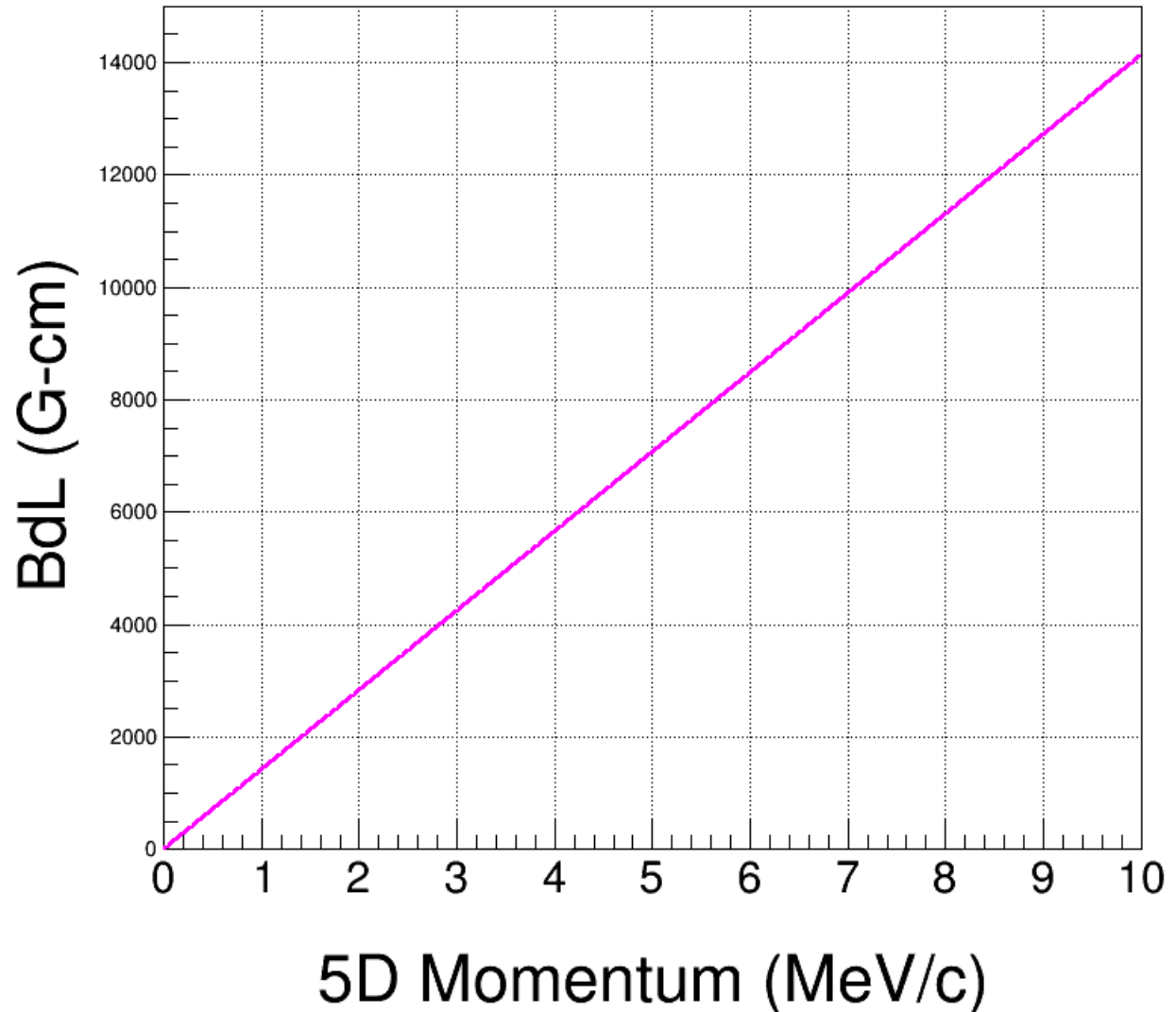
- For Bubble Chamber, we are especially interested in momenta around 5.5 MeV/c (fluorine measurement) and 8.5 MeV/c (oxygen measurement)
- Corresponding magnet currents are 3.2 A and 5.0 A. At these currents, Trim card is good to about 1 to 2 mA.

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**

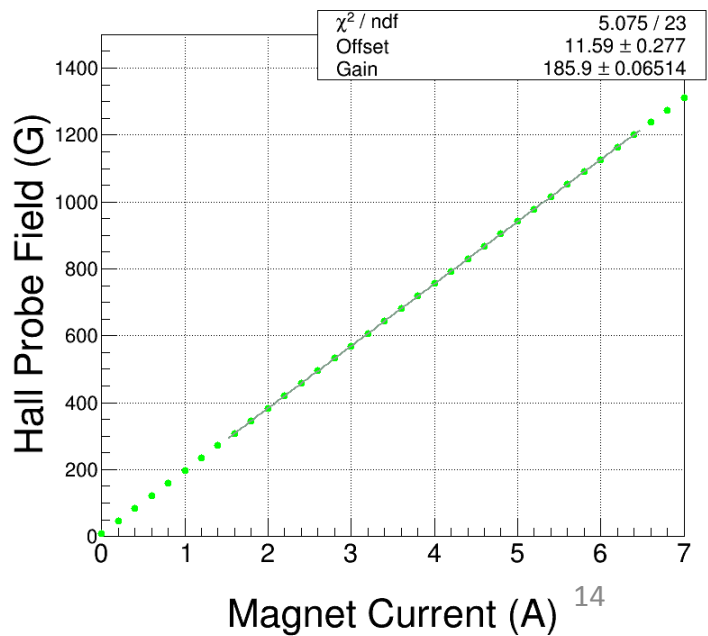
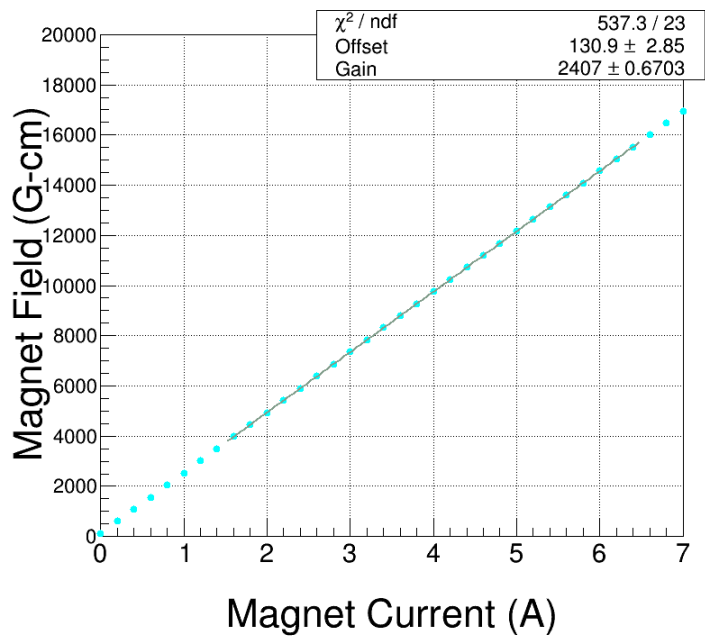
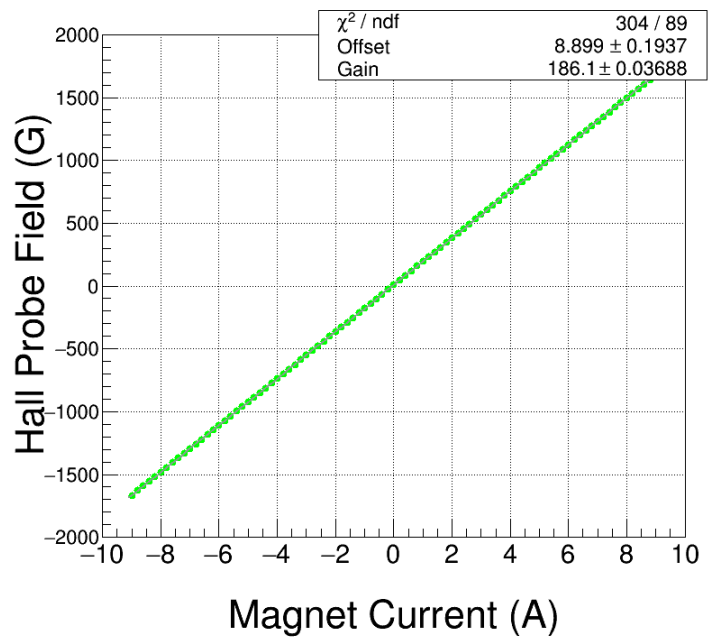
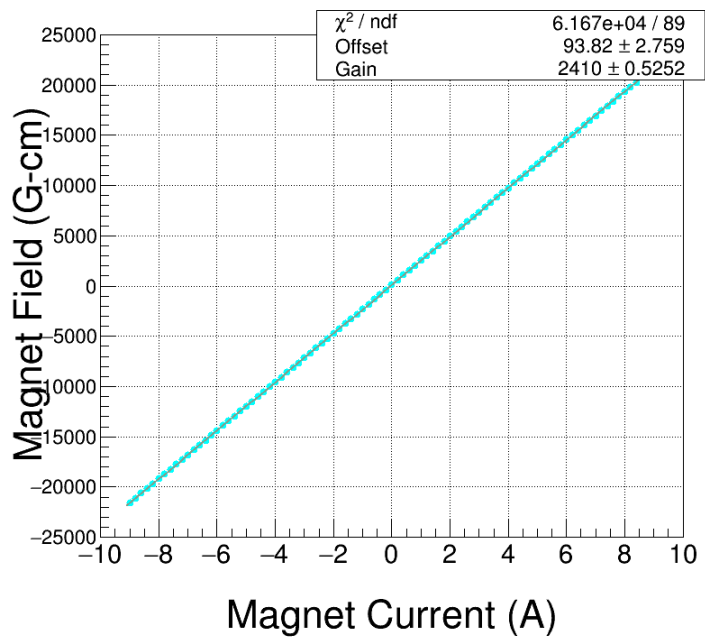
From Field Map

Current (A) Hall Probe (G)

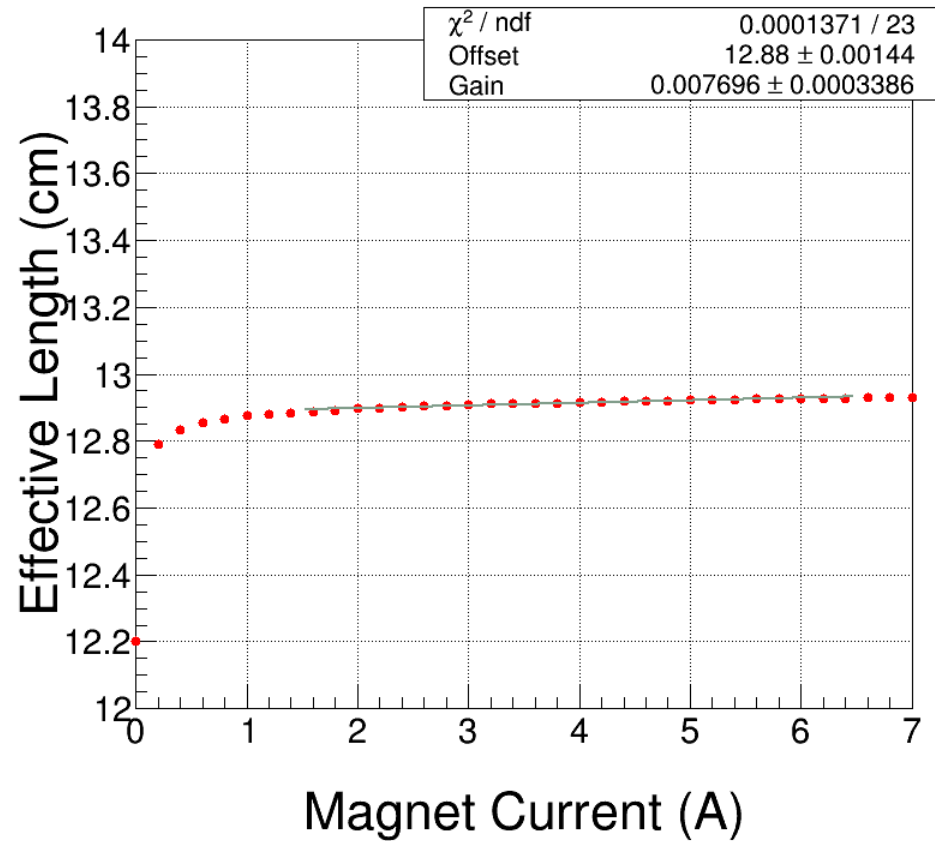
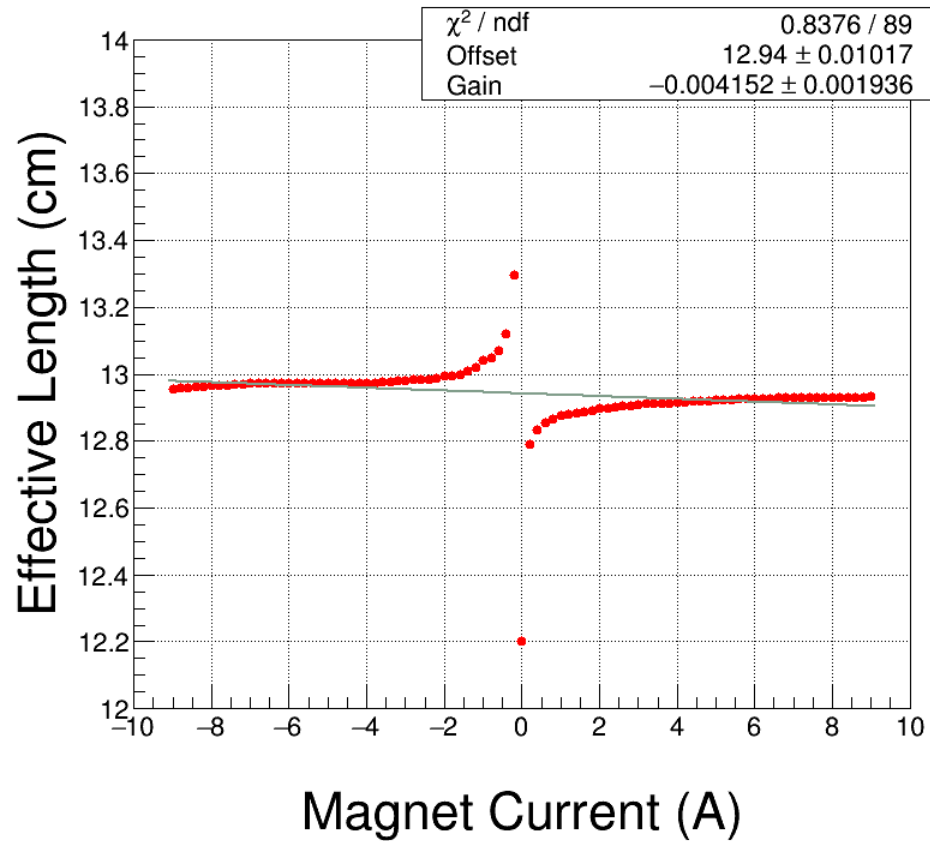
9.0	1676.84
8.0	1494.811
7.0	1311.098
6.0	1126.72
5.0	941.599
4.0	755.813
3.0	569.625
2.0	382.975
1.0	196.247
0.0	9.73
-1.0	-176.974
-2.0	-363.63
-3.0	-550.311
-4.0	-736.641
-5.0	-922.818
-6.0	-1108.806
-7.0	-1294.494
-8.0	-1480.191
-9.0	-1665.526

From Current Scan

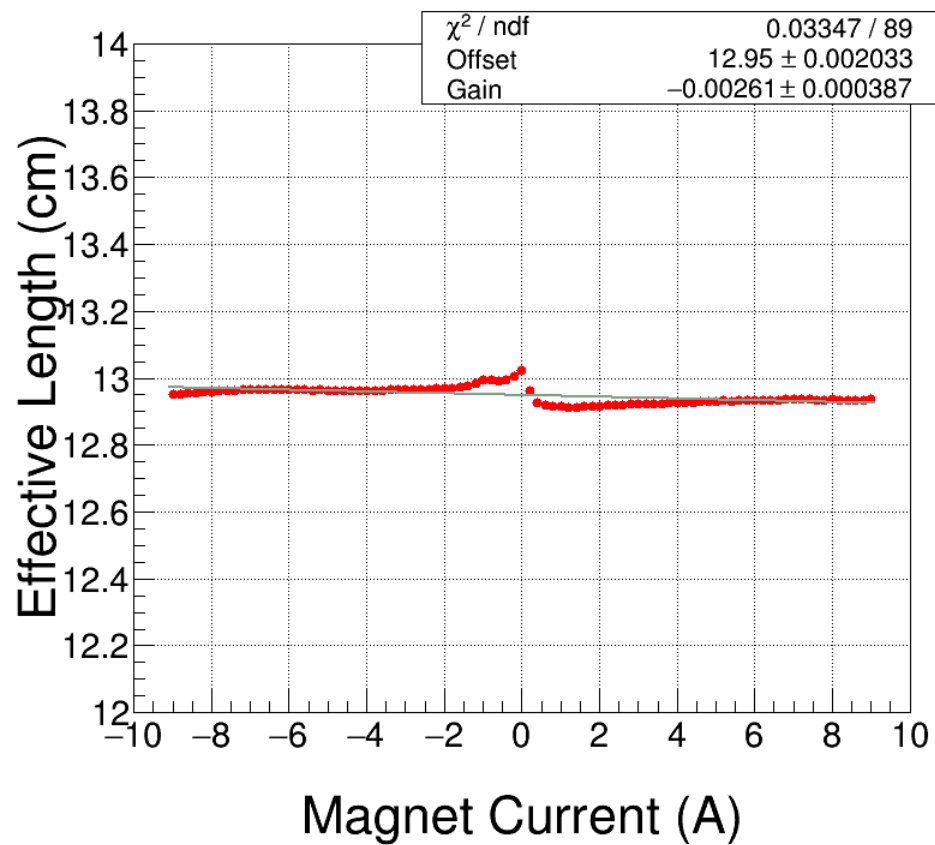
Current (A)	Core Field (G)
10.01	1863.40
9.01	1682.70
8.01	1499.15
7.01	1314.35
6.01	1128.70
5.01	942.75
4.01	756.15
3.01	569.25
2.01	382.25
1.01	195.15
0.00	7.40
-0.99	-179.45
-1.99	-366.65
-2.99	-554.15
-3.99	-742.50
-4.99	-929.65
-5.99	-1116.25
-6.99	-1302.90
-7.99	-1489.25
-9.00	-1675.60
-9.99	-1860.05



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**

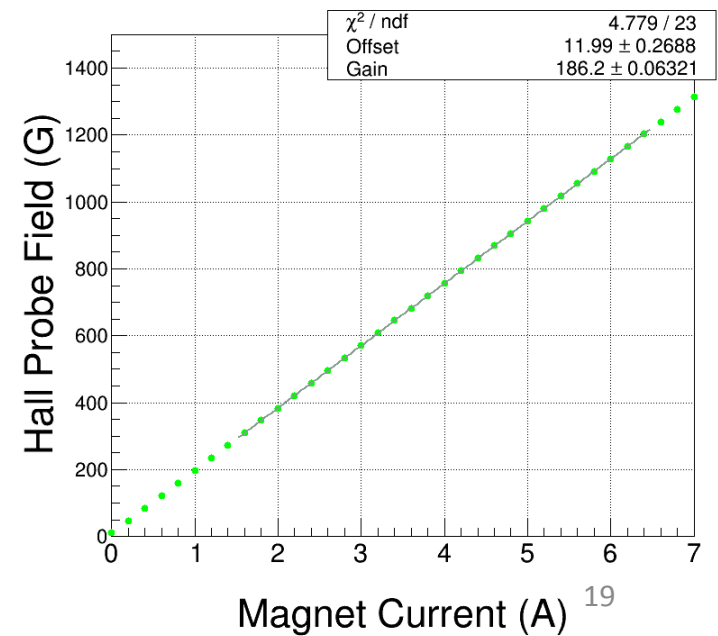
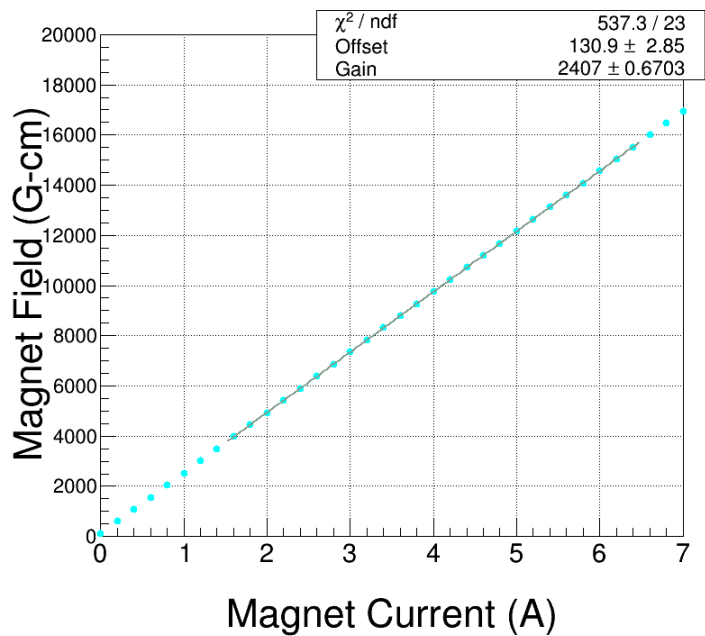
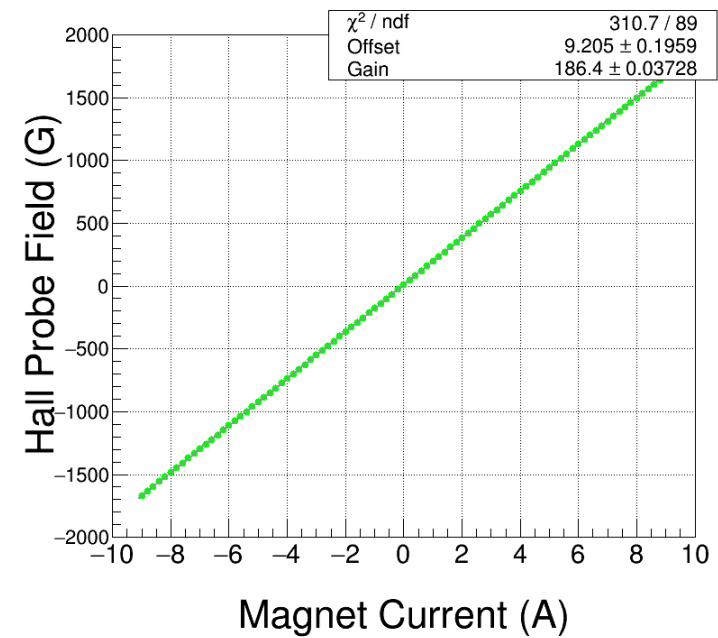
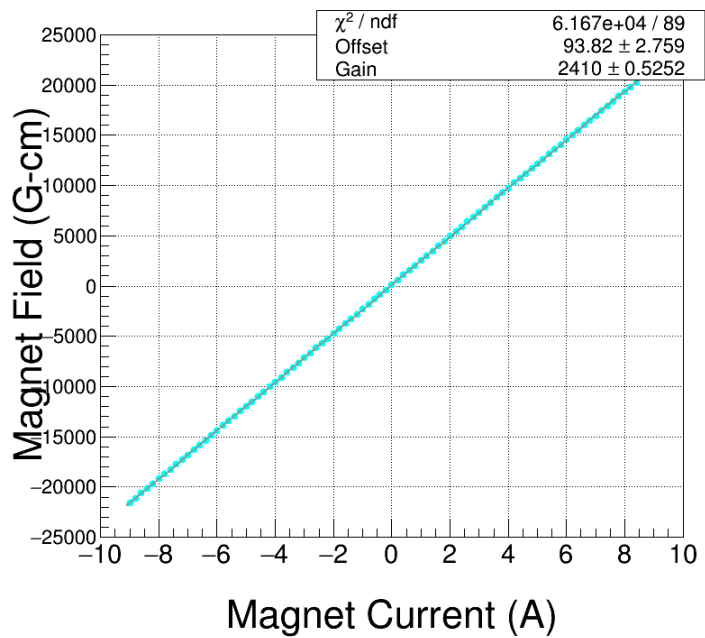
From Field Map

Current (A) Hall Probe (G)

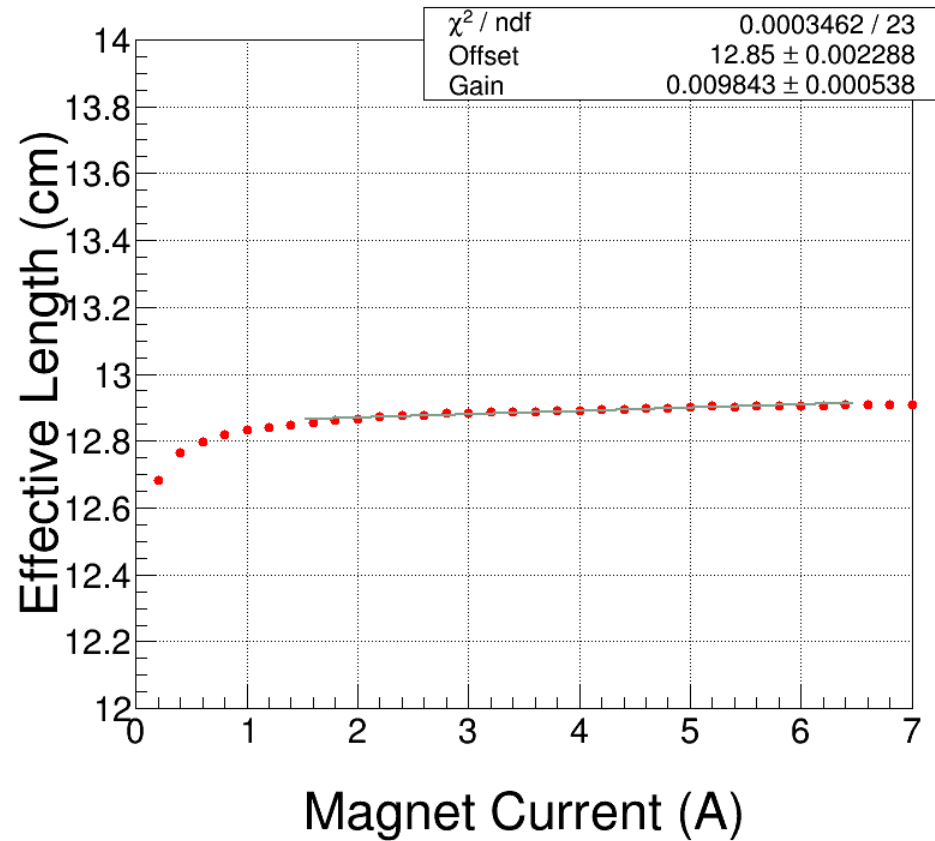
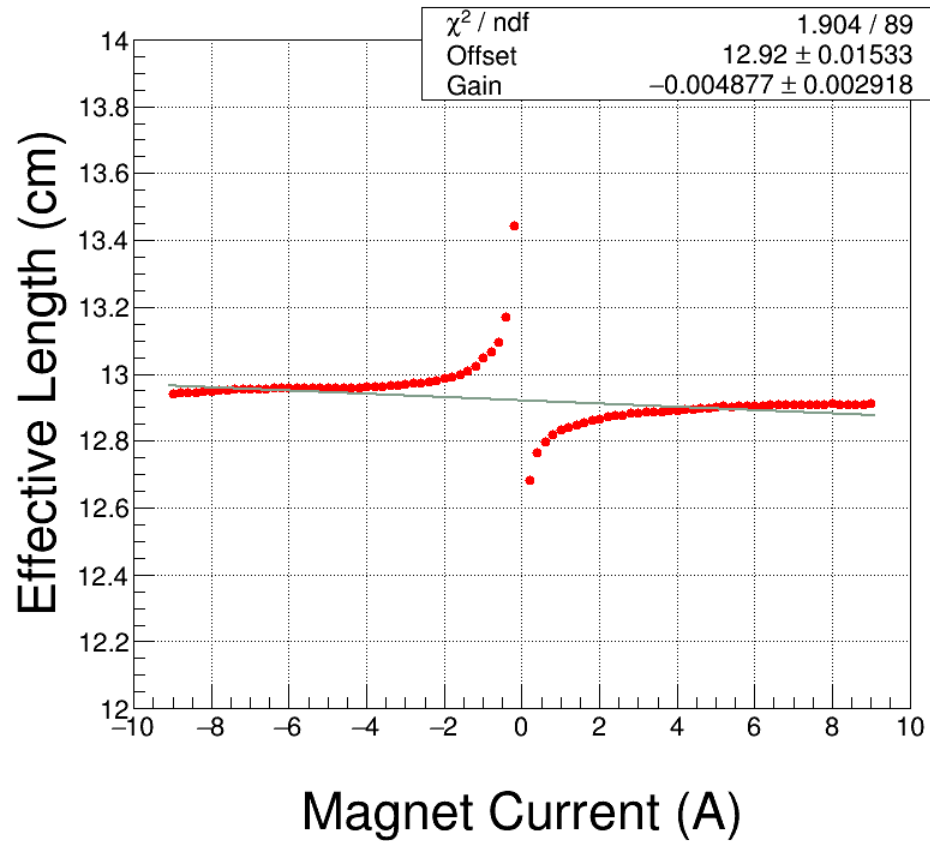
9.0	1679.413
8.0	1497.175
7.0	1313.228
6.0	1128.575
5.0	943.145
4.0	757.186
3.0	570.716
2.0	383.856
1.0	196.884
0.0	10.084
-1.0	-176.862
-2.0	-363.784
-3.0	-550.767
-4.0	-737.396
-5.0	-923.895
-6.0	-1110.12
-7.0	-1296.09
-8.0	-1481.945
-9.0	-1667.458

From Current Scan

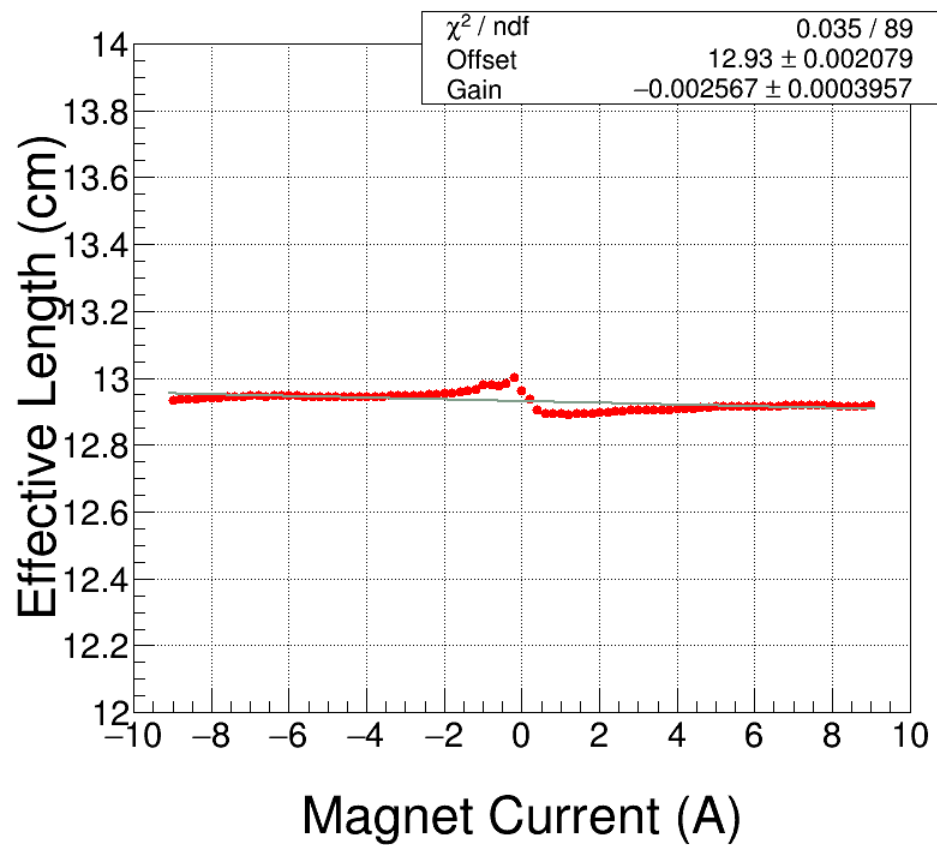
Current (A)	Core Field (G)
10.01	1863.40
9.01	1682.70
8.01	1499.15
7.01	1314.35
6.01	1128.70
5.01	942.75
4.01	756.15
3.01	569.25
2.01	382.25
1.01	195.15
0.00	7.40
-0.99	-179.45
-1.99	-366.65
-2.99	-554.15
-3.99	-742.50
-4.99	-929.65
-5.99	-1116.25
-6.99	-1302.90
-7.99	-1489.25
-9.00	-1675.60
-9.99	-1860.05



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 Hall Probe field in Injector is a bit too large when BdL is set to zero
 2. Effective Length from Field Map depends on magnet current

Due to errors in measuring 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.

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

For Mott Energy Measurements