Survey Analysis

Validity of MWD survey data using graphical representation and the application of potential bias corrections

Topics of Discussion

- Input Parameters
- Data Tables
  - Input Data
  - Raw Calculated Data
  - DIY Calculated Data
- Example Case Study
  - Tables
  - Charts

Survey Analysis

What if Scenarios – Tool Calibration and/or Bias Errors

1. Calculate Geomagnetic Reference Model values
2. Apply Model or Infield Reference (IFR) values to data
3. Read downhole MWD measured values
4. Calculate Total Field, Dip, Gravity Totals, Inclination and Azimuth etc.
5. Graphical plots of calculated data
6. DIY – “Do It Yourself” scenarios
7. Recognition of potential MWD Instrumentation Issues
8. Application of probable Bias Correction (where appropriate)
9. Justification of applied Bias Corrections
10. Decision – Reliable, Trip, Resurvey?

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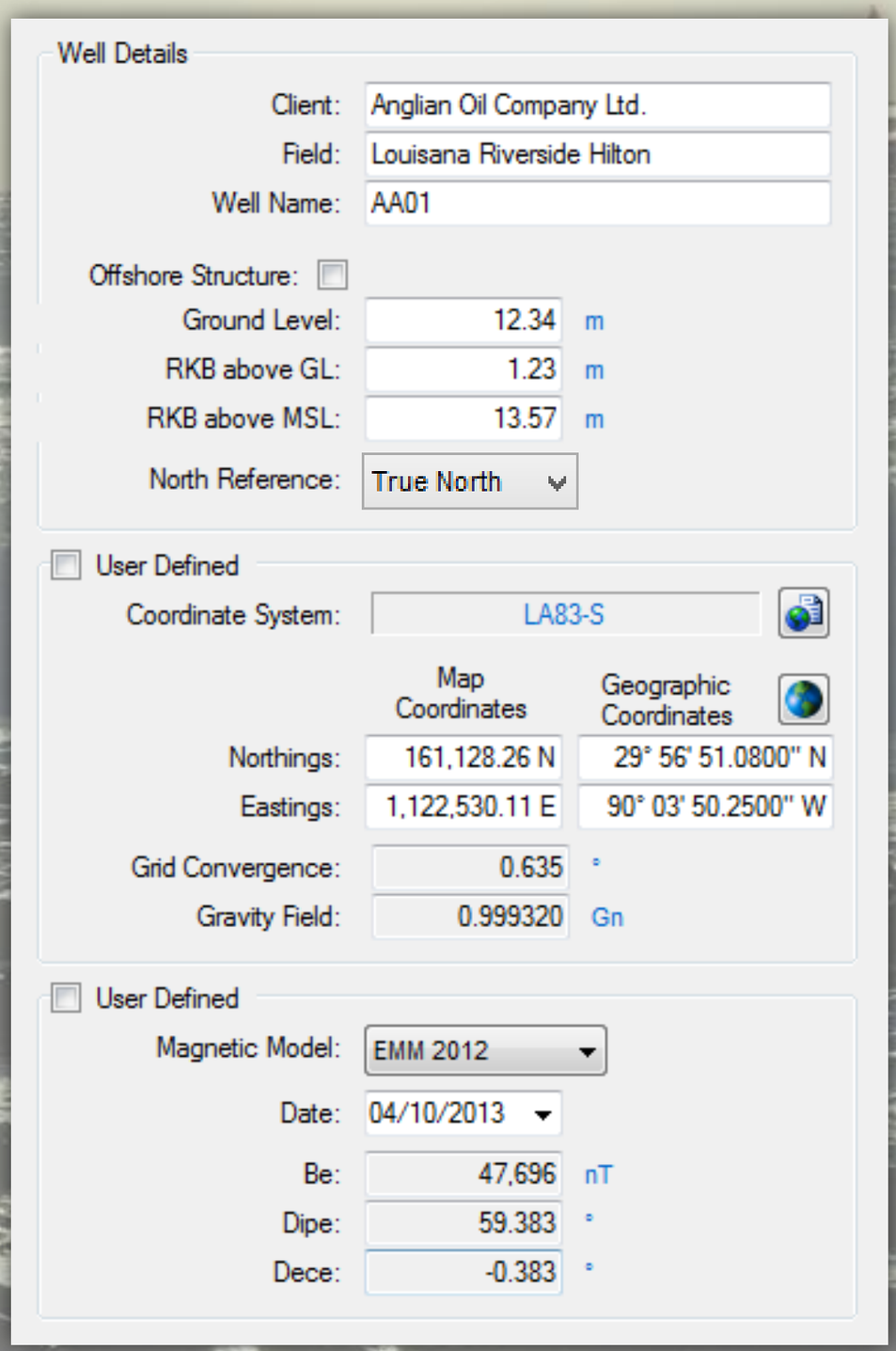
Input Parameters

- Well details
- Geographical Location
- Geomagnetic Model Values
- Input data values – user defined option for local IFR data



Data Tables – Input Data

- **Sensor values with Model/IFR data applied**

Run No.	Survey Depth (m)	Measured Gx (G)	Measured Gy (G)	Measured Gz (G)	Measured Bx (nT)	Measured By (nT)	Measured Bz (nT)	Earth's Bt (nT)	Earth's Dip (°)
100	0.00	0.001000	-0.001500	0.999050	13,259	-20,388	45,560	47,696	59.383
100	49.40	-0.005790	0.000090	0.998780	-23,322	7,796	45,371	47,696	59.383
100	50.50	-0.012750	-0.000800	0.998550	-21,365	12,591	45,210	47,696	59.383
100	53.40	-0.002200	0.010990	0.998320	-2,205	24,626	45,277	47,696	59.383
100	77.40	0.006300	-0.006030	0.998300	24,537	632	45,397	47,696	59.383
100	105.40	-0.002680	0.002220	0.998800	-13,361	20,473	45,406	47,696	59.383
100	133.40	0.007140	0.001810	0.999650	22,455	-9,754	45,445	47,696	59.383
100	161.40	0.010460	0.002950	0.998420	24,568	-2,378	45,325	47,696	59.383
100	166.40	0.011450	-0.001260	0.998490	21,090	-12,803	45,346	47,696	59.383
100	173.80	-0.000150	-0.015230	0.999420	-13,264	-20,953	45,225	47,696	59.383

Data Tables – Raw Data

- MWD tool values calculated from tool sensor values
  - dB = Raw Bt - Be
  - dDip = Raw Dip - Dipe

Run No.	Survey Depth (m)	Earth's Bt (nT)	Raw Bt (nT)	Raw dB (nT)	Earth's Dip (°)	Raw Dip (°)	Raw dDip (°)	Raw BtDip Calc (nT)	Raw Inclination (°)	LC Azimuth (°)	Highside Toolface (°)
100	0.00	47,696	51,645	3,949	59.383	62.010	2.626	5,615	0.103	179.637	236.310
100	49.40	47,696	51,606	3,911	59.383	61.859	2.476	5,575	0.332	196.762	0.891
100	50.50	47,696	51,565	3,869	59.383	61.858	2.475	5,524	0.733	213.850	356.410
100	53.40	47,696	51,588	3,892	59.383	62.002	2.618	5,547	0.643	185.316	78.680
100	77.40	47,696	51,608	3,912	59.383	61.951	2.568	5,572	0.500	133.095	223.746
100	105.40	47,696	51,569	3,873	59.383	61.892	2.509	5,527	0.200	196.327	39.637
100	133.40	47,696	51,620	3,924	59.383	62.021	2.637	5,585	0.422	217.171	165.775
100	161.40	47,696	51,610	3,914	59.383	62.009	2.625	5,574	0.624	200.685	164.250
100	166.40	47,696	51,623	3,927	59.383	62.048	2.665	5,589	0.661	204.487	186.280
100	173.80	47,696	51,578	3,882	59.383	62.001	2.618	5,535	0.873	211.615	270.564

Data Tables – DIY Data

- **Application of potential biases to MWD sensor data**

Run No.	Survey Depth (m)	Earth's Bt (nT)	Diy Bt (nT)	Diy dB (nT)	Earth's Dip (°)	Diy Dip (°)	Diy dDip (°)	Diy BtDip Calc (nT)			
100	0.00	47,696	47,699	4	59.383	59.407	0.024	10			
100	49.40	47,696	47,715	19	59.383	59.332	-0.051	39			
100	50.50	47,696	47,688	-8	59.383	59.311	-0.072	28			
100	53.40	47,696	47,709	13	59.383	59.458	0.074	33			
100	77.40	47,696	47,688	-8	59.383	59.344	-0.039	19			
100	105.40	47,696	47,677	-18	59.383	59.384	0.001	31			
100	133.40	47,696	47,688	-7	59.383	59.405	0.022	16			
100	161.40	47,696	47,694	-1	59.383	59.382	-0.001	2			
100	166.40	47,696	47,699	4	59.383	59.410	0.027	11			
100	173.80	47,696	47,669	-27	59.383	59.383	0.000	45	0.790	207.235	274.788

DIY Values (Run #100)

Same as Previous ☐

Accelerometer Biases:

dGx:	0.001000	G
dGy:	-0.001500	G
dGz:	0.000000	G

Magnetometer Biases:

dBx:	20	nT
dBy:	-40	nT
dBz:	4,500	nT

Magnetometer Scale Factors:

Sx:	0.00	%
Sy:	0.00	%
Sz:	0.00	%

Apply

Chart of Inclination vs Measured Depth

- Gt, Bt and Dip should be constant through full range of inclination

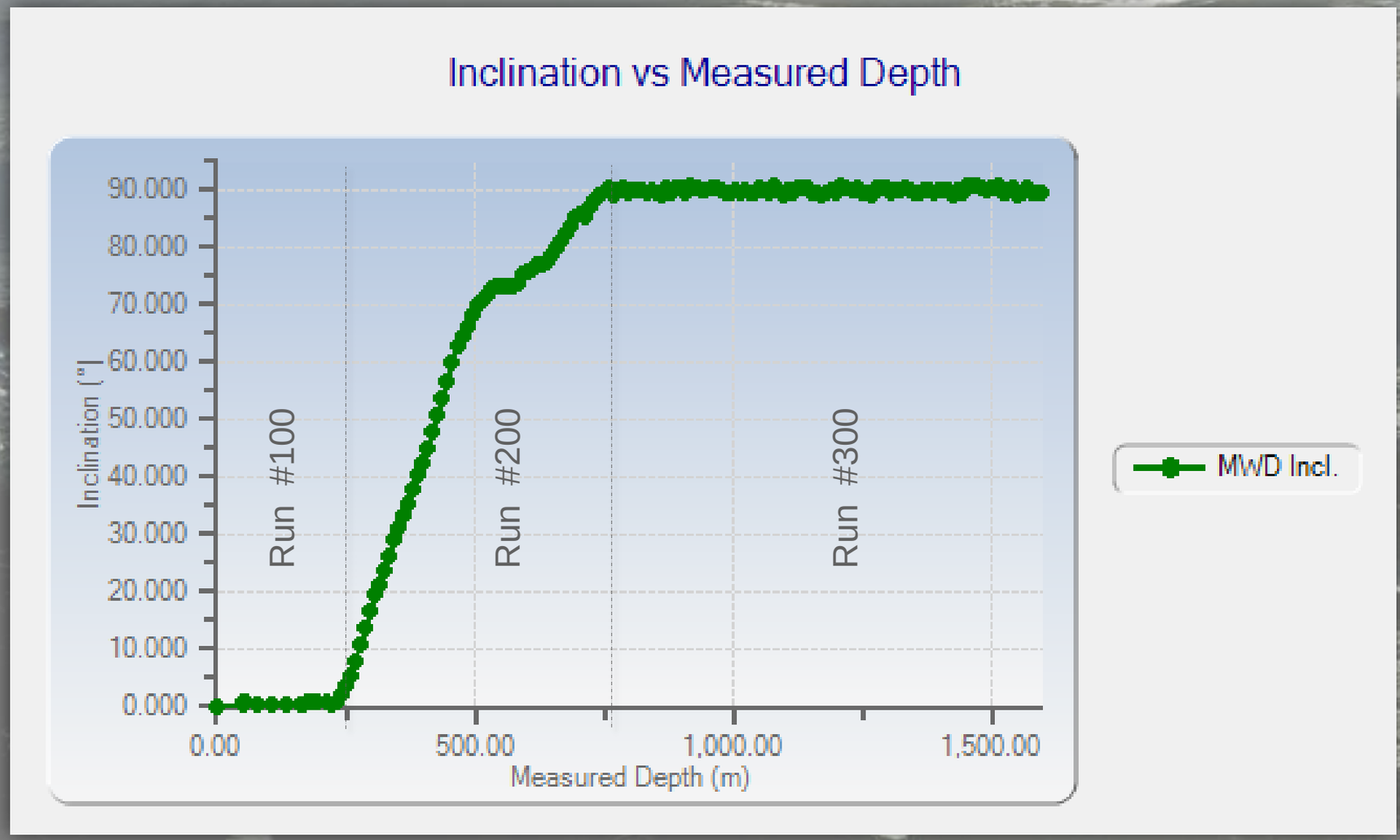
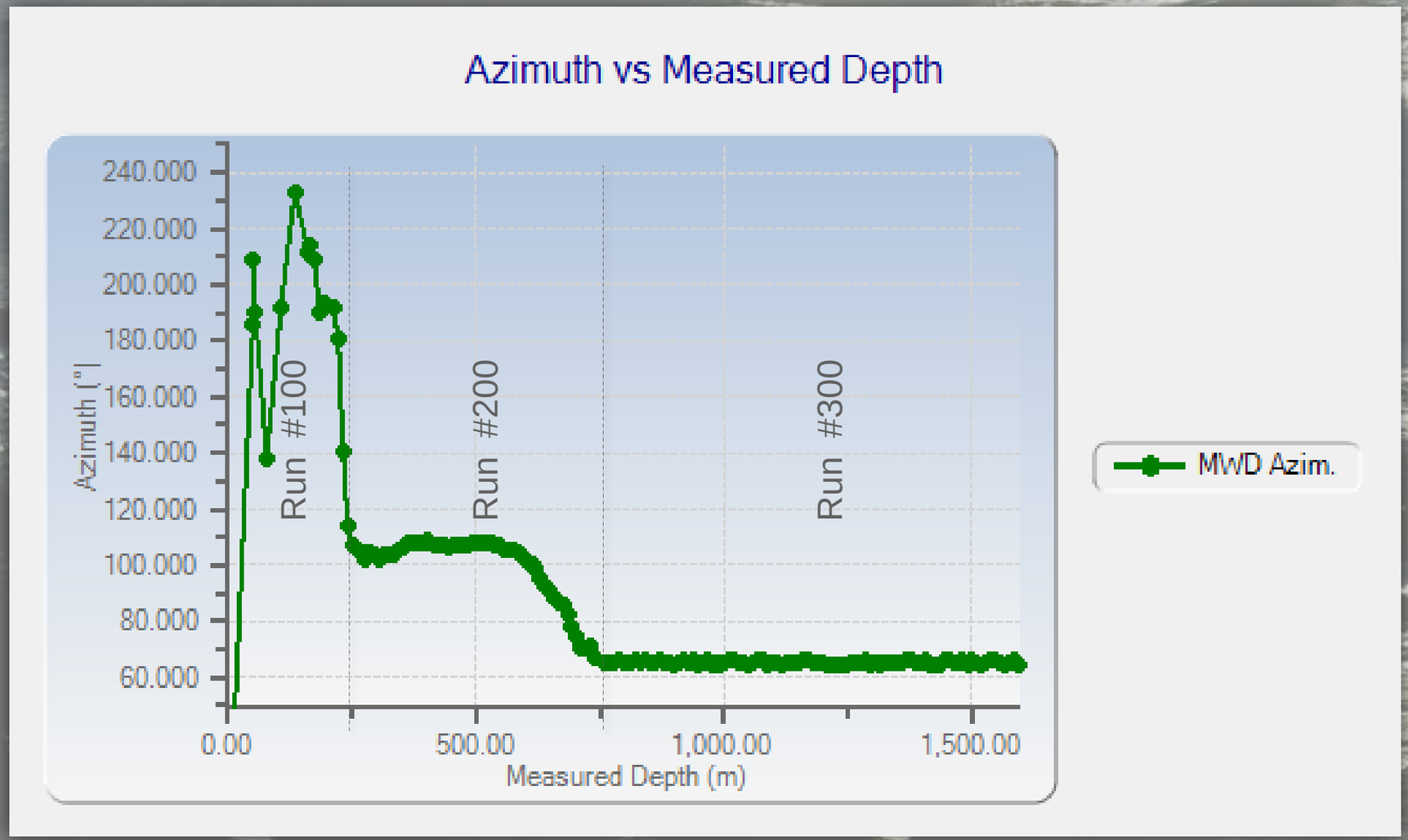


Chart of Azimuth vs Measured Depth

- Gt, Bt and Dip should be constant through full range of azimuth



Correction of Gx and Gy Accelerometers

- **Run 300**

DIY Values (Run #300)

Same as Previous ☐

Accelerometer Biases:

dGx:	0.000000	G
dGy:	0.000000	G
dGz:	0.000000	G

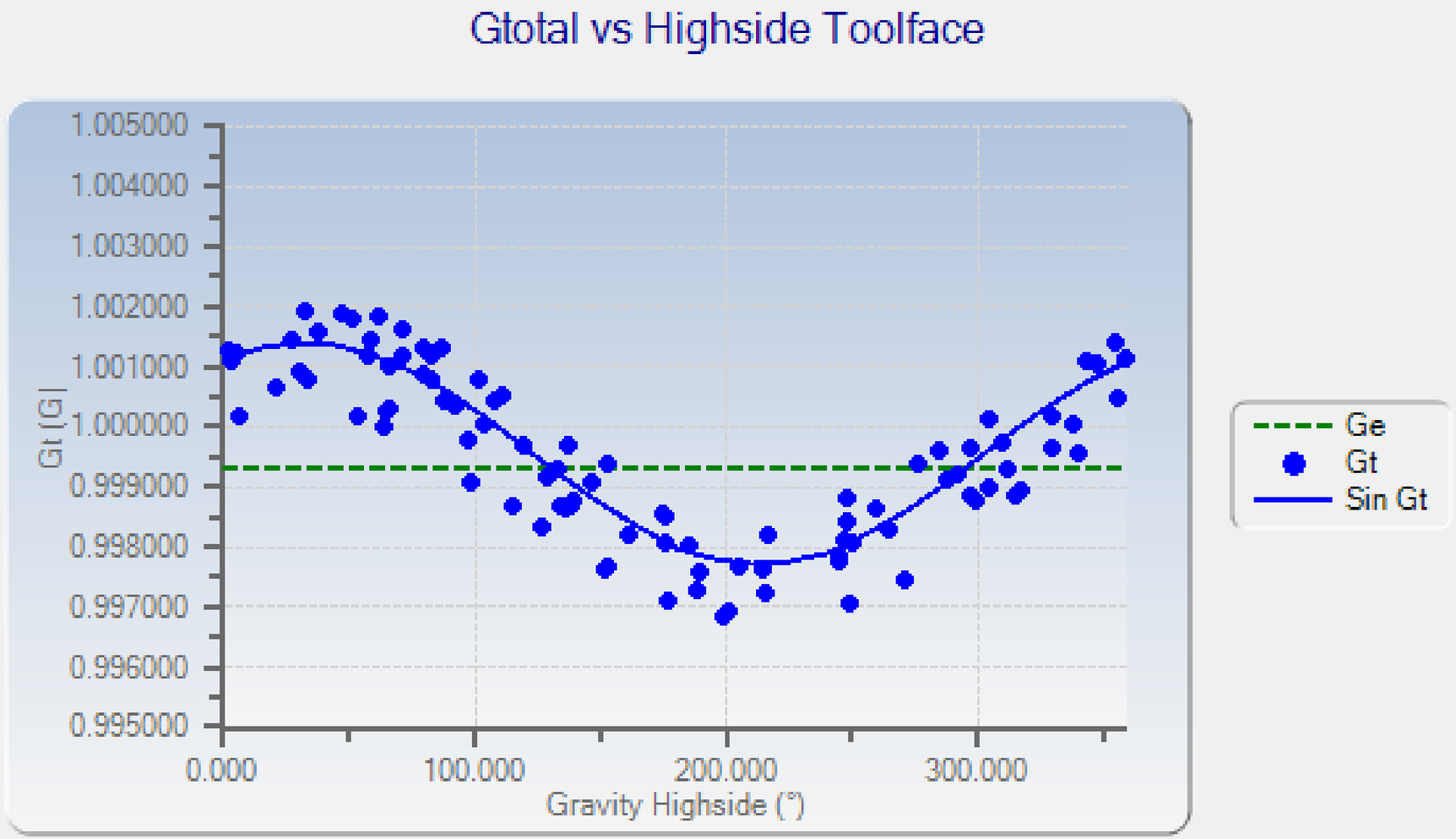
Magnetometer Biases:

dBx:	0	nT
dBy:	0	nT
dBz:	0	nT

Magnetometer Scale Factors:

Sx:	0.00	%
Sy:	0.00	%
Sz:	0.00	%

Apply



Correction of Gx and Gy Accelerometers

- **Run 300**

DIY Values (Run #300)

Same as Previous ☐

Accelerometer Biases:

dGx:	-0.001500	G
dGy:	0.001000	G
dGz:	0.000000	G

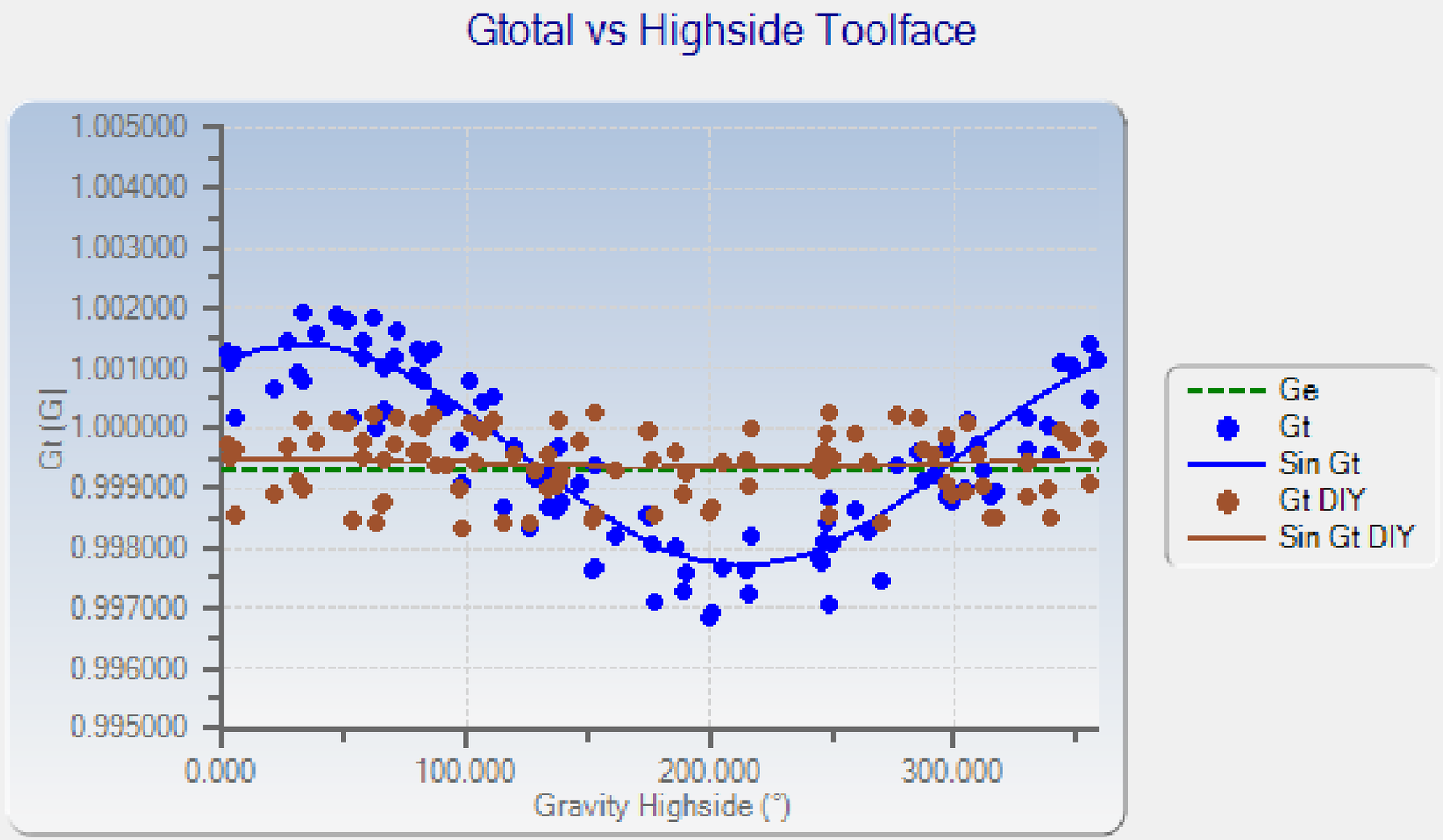
Magnetometer Biases:

dBx:	0	nT
dBy:	0	nT
dBz:	0	nT

Magnetometer Scale Factors:

Sx:	0.00	%
Sy:	0.00	%
Sz:	0.00	%

Apply



Correction of Bz Magnetometer, Btotal

- **DIY Values for Run 200**

DIY Values (Run #200)

Same as Previous ☐

Accelerometer Biases:

dGx:	-0.000500	G
dGy:	0.002000	G
dGz:	0.000000	G

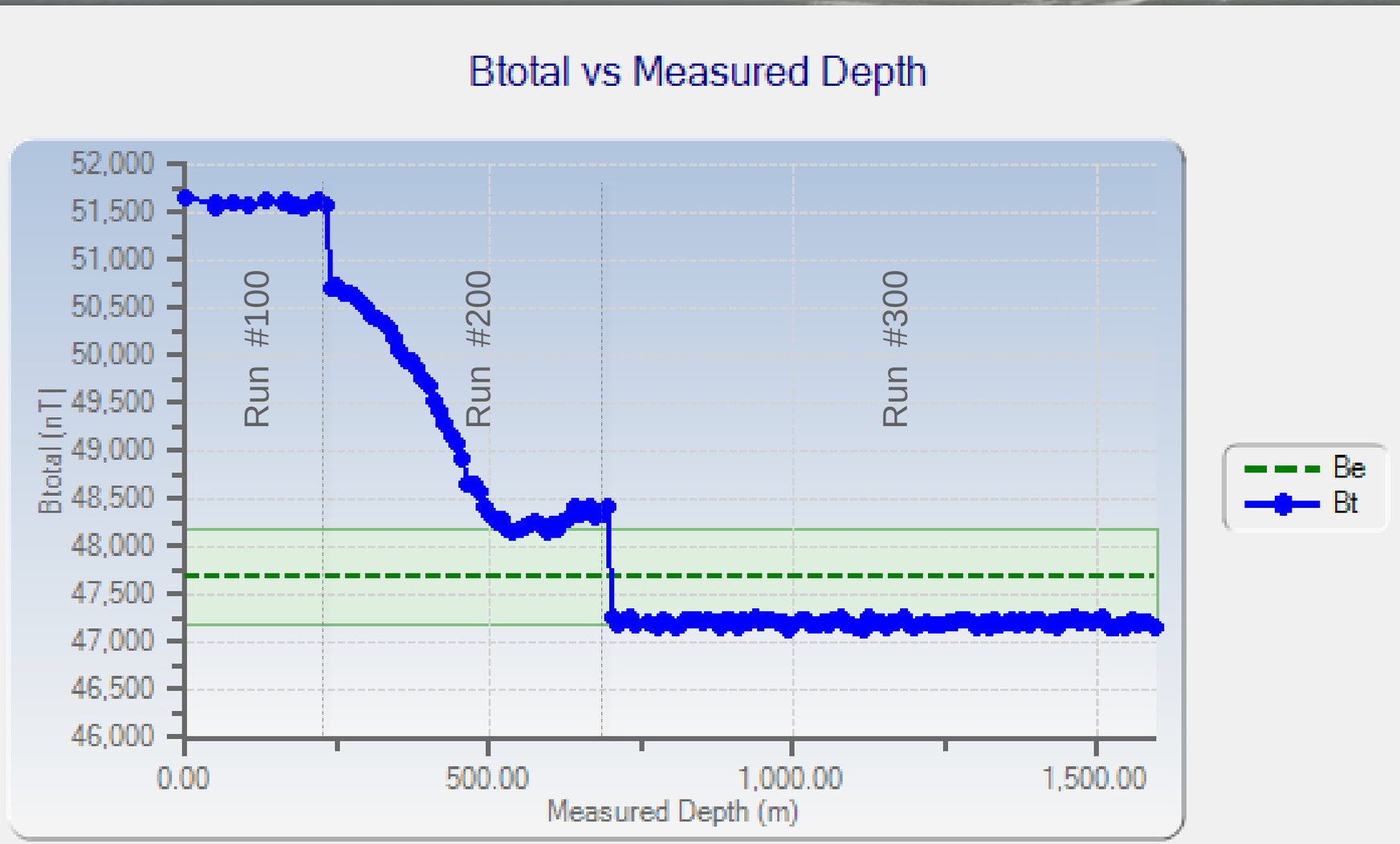
Magnetometer Biases:

dBx:	0	nT
dBy:	0	nT
dBz:	0	nT

Magnetometer Scale Factors:

Sx:	0.00	%
Sy:	0.00	%
Sz:	0.00	%

Apply



Correction of Bz Magnetometer, Btotal

- **DIY Values for Run 200, dBz +3500nt**

DIY Values (Run #200)

Same as Previous ☐

Accelerometer Biases:

dGx:	-0.000500	G
dGy:	0.002000	G
dGz:	0.000000	G

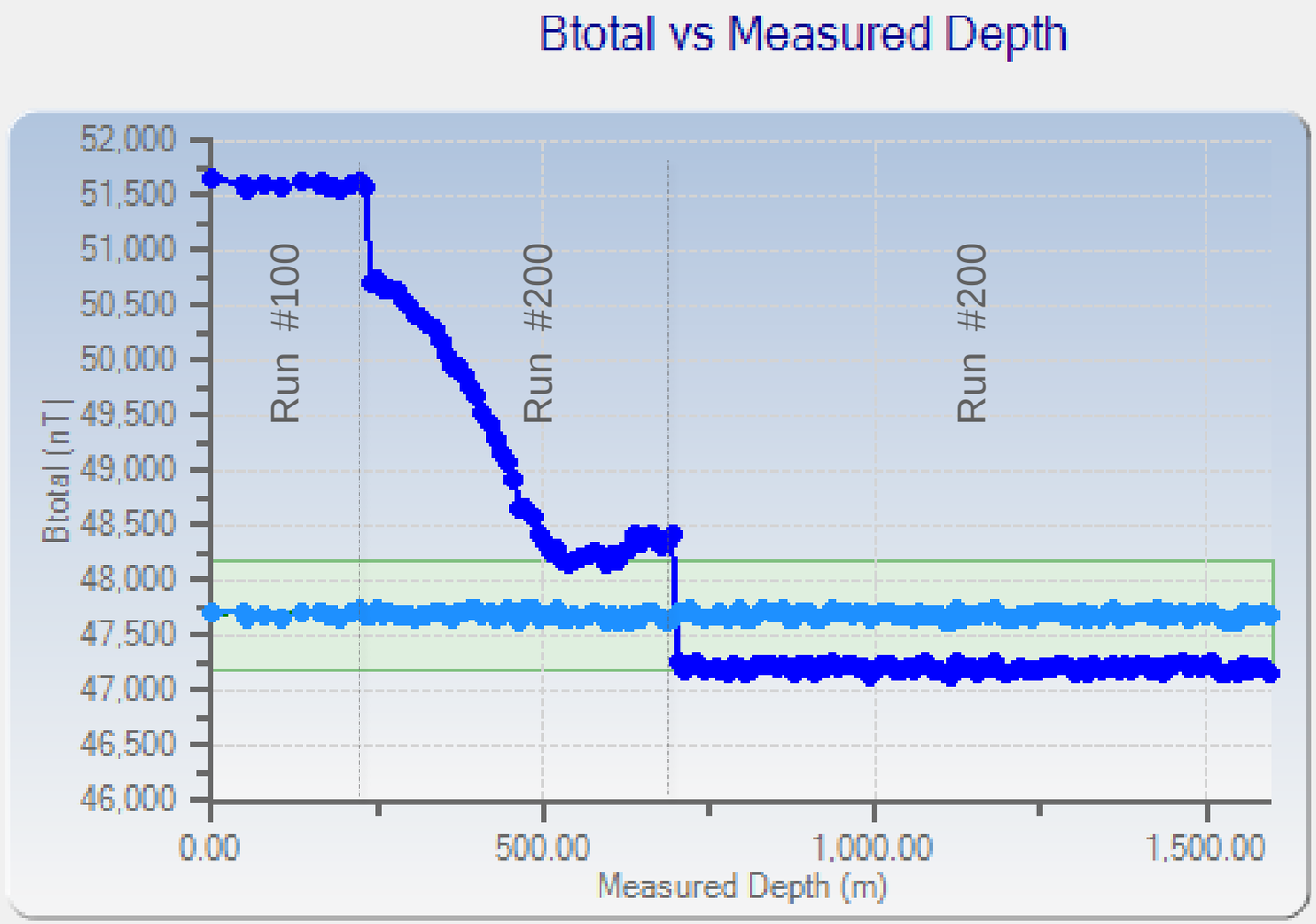
Magnetometer Biases:

dBx:	0	nT
dBy:	0	nT
dBz:	3,500	nT

Magnetometer Scale Factors:

Sx:	0.00	%
Sy:	0.00	%
Sz:	0.00	%

Apply



Correction of Bz Magnetometer, Dip

- **DIY Values for Run 200**

DIY Values (Run #200)

Same as Previous ☐

Accelerometer Biases:

dGx:	-0.000500	G
dGy:	0.002000	G
dGz:	0.000000	G

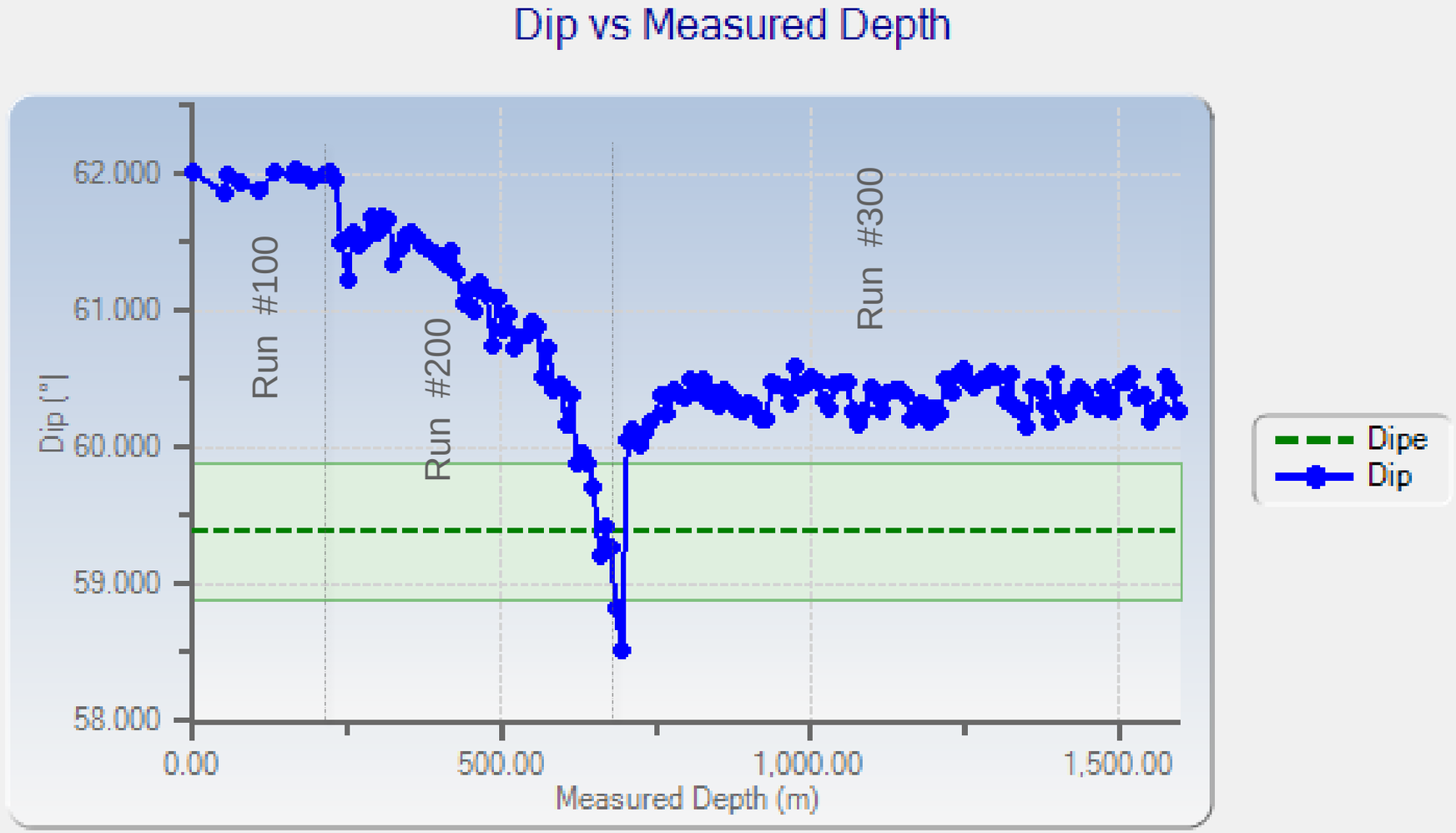
Magnetometer Biases:

dBx:	0	nT
dBy:	0	nT
dBz:	0	nT

Magnetometer Scale Factors:

Sx:	0.00	%
Sy:	0.00	%
Sz:	0.00	%

Apply



Correction of Bz Magnetometer, Dip

- **DIY Values for Run 200, dBz +3500nt**

DIY Values (Run #200)

Same as Previous ☐

Accelerometer Biases:

dGx:	-0.000500	G
dGy:	0.002000	G
dGz:	0.000000	G

Magnetometer Biases:

dBx:	0	nT
dBy:	0	nT
dBz:	3,500	nT

Magnetometer Scale Factors:

Sx:	0.00	%
Sy:	0.00	%
Sz:	0.00	%

Apply

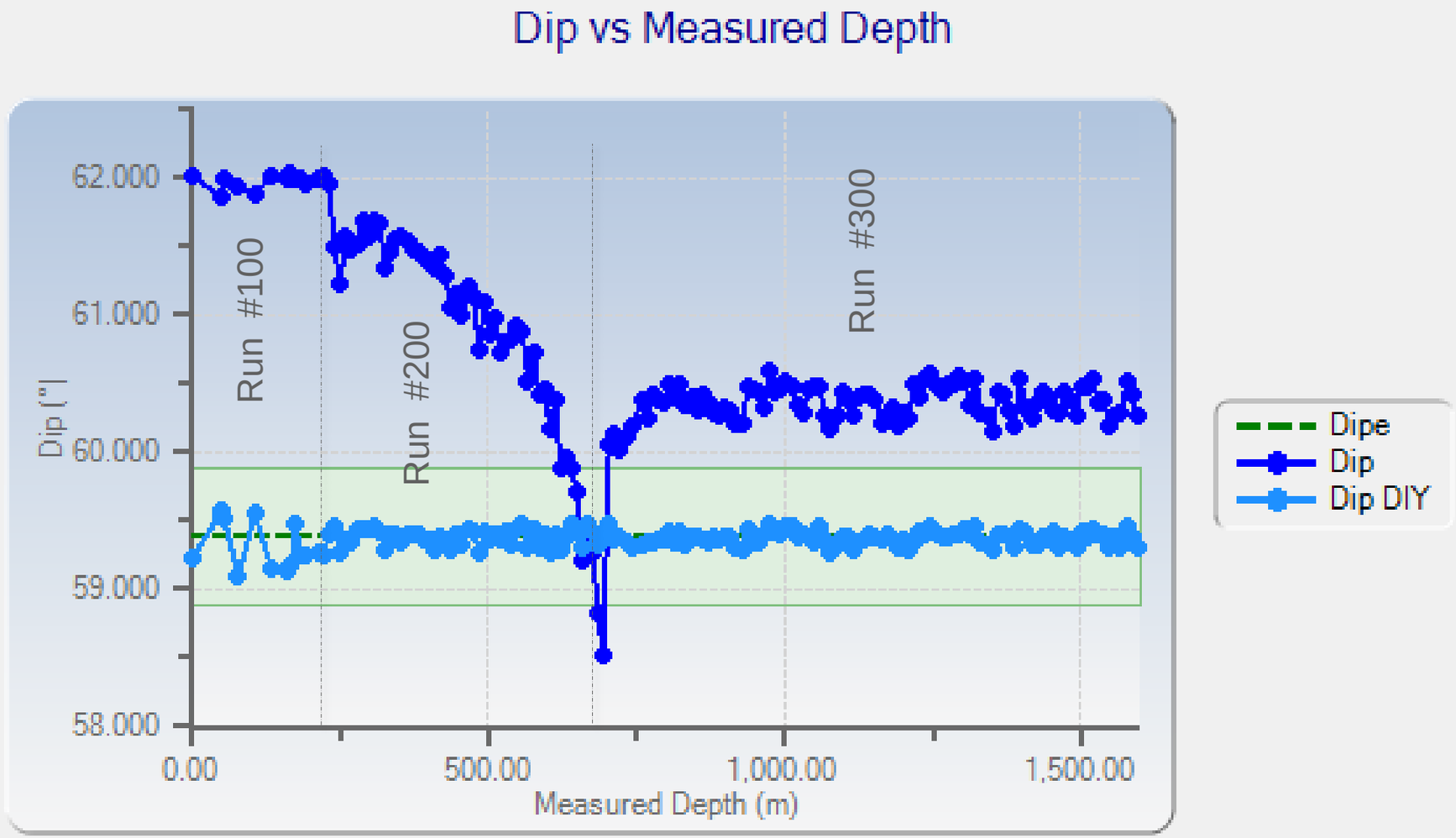


Chart of BtDip vs Measured Depth

- **DIY Values for Run 200**

DIY Values (Run #200)

Same as Previous ☐

Accelerometer Biases:

dGx:	-0.000500	G
dGy:	0.002000	G
dGz:	0.000000	G

Magnetometer Biases:

dBx:	0.00	nT
dBy:	0.00	nT
dBz:	3,500	nT

Magnetometer Scale Factors:

Sx:	0.00	%
Sy:	0.00	%
Sz:	0.00	%

Apply

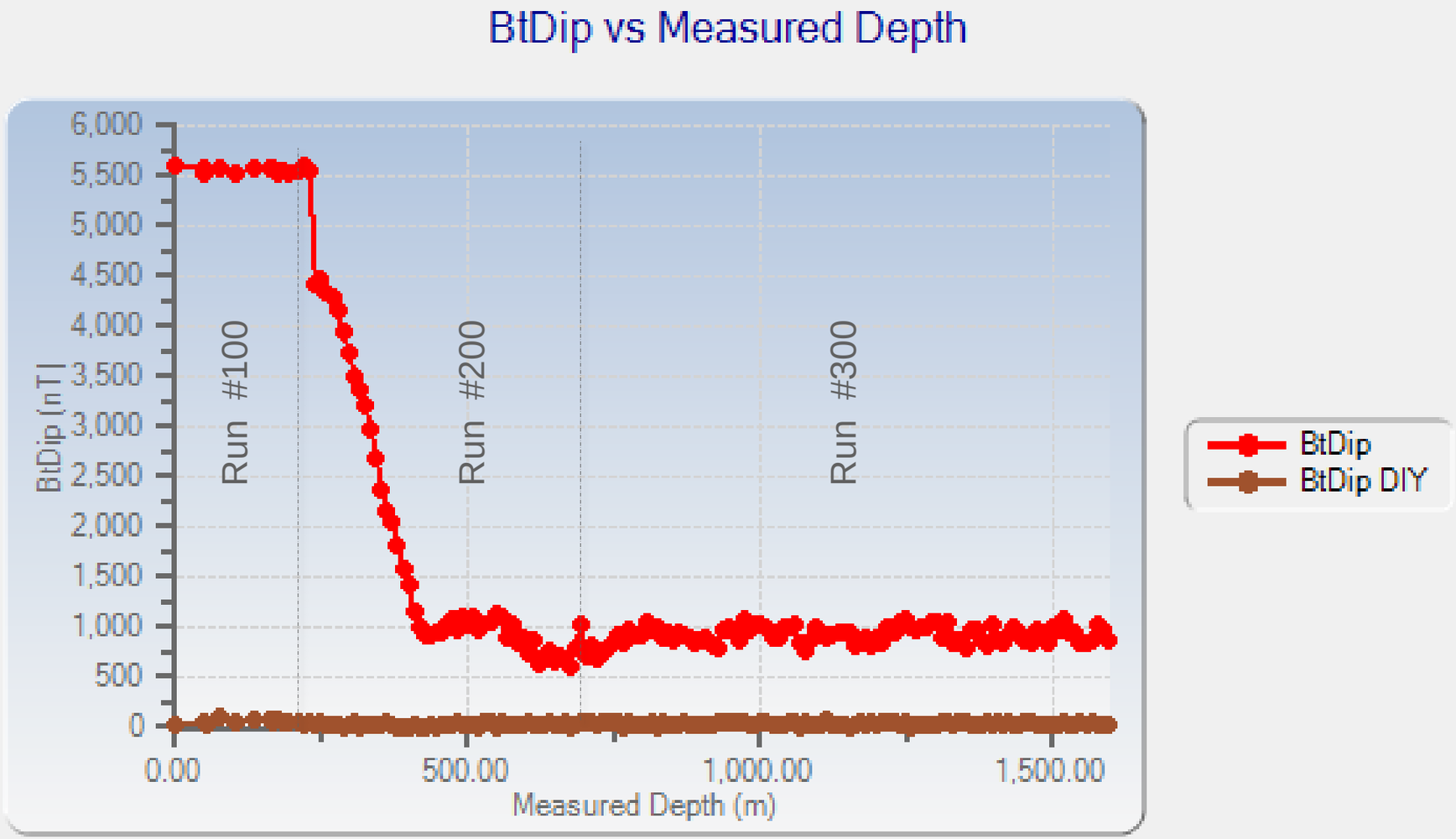


Chart of Azimuth vs Measured Depth

- **DIY Values for Run 200**

DIY Values (Run #200)

Same as Previous ☐

Accelerometer Biases:

dGx:	-0.000500	G
dGy:	0.002000	G
dGz:	0.000000	G

Magnetometer Biases:

dBx:	0.00	nT
dBy:	0.00	nT
dBz:	3,500	nT

Magnetometer Scale Factors:

Sx:	0.00	%
Sy:	0.00	%
Sz:	0.00	%

Apply

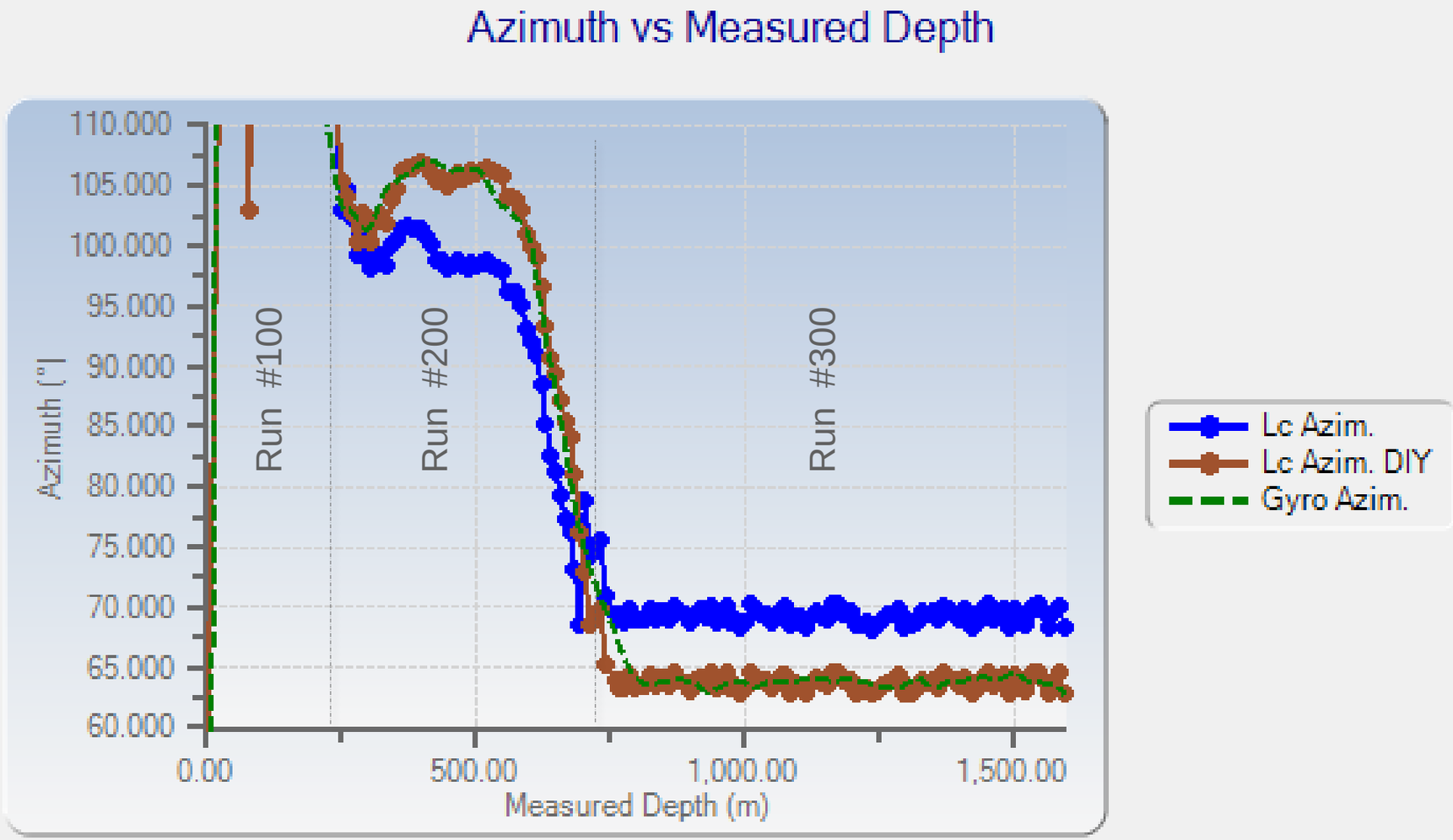


Chart of dBh and dBv vs Measured Depth

- **DIY Values for Run 200**

DIY Values (Run #200)

Same as Previous ☐

Accelerometer Biases:

dGx:	-0.000500	G
dGy:	0.002000	G
dGz:	0.000000	G

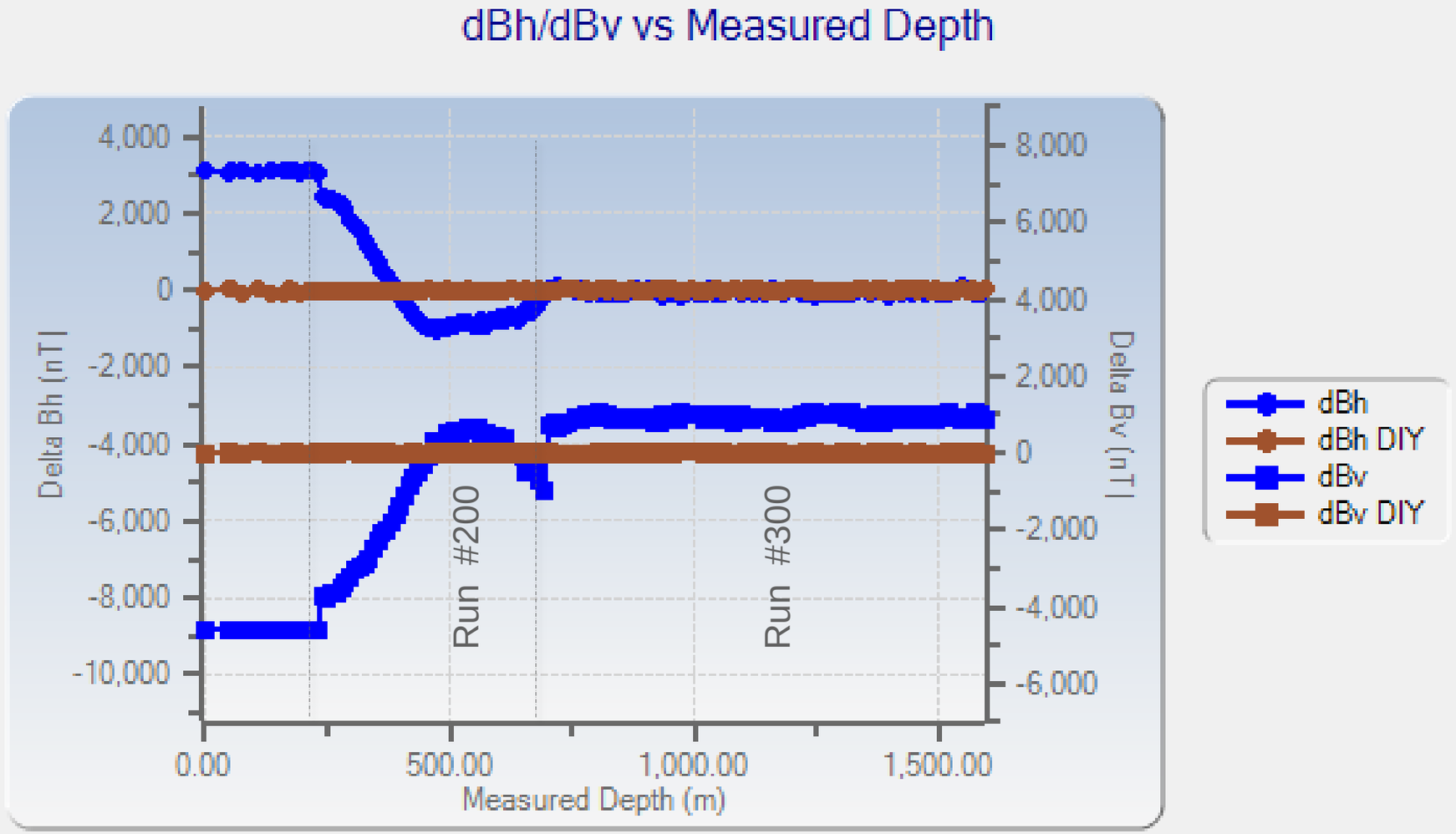
Magnetometer Biases:

dBx:	0.00	nT
dBy:	0.00	nT
dBz:	3,500	nT

Magnetometer Scale Factors:

Sx:	0.00	%
Sy:	0.00	%
Sz:	0.00	%

Apply



Bottom Hole Location

Survey Analysis – Application

- Data tables of MWD raw sensor data and calculated values
- Graphical Representation of QC Data
- Utilize “What if” Scenarios to determine potential biasing
- Allows recognition of
  - Potential problems with MWD
  - Potential assembly biasing
  - Potential influence of biasing upon azimuth

Questions!