IADC/SPE 87977

MWD Survey Accuracy Improvements Using Multistation Analysis

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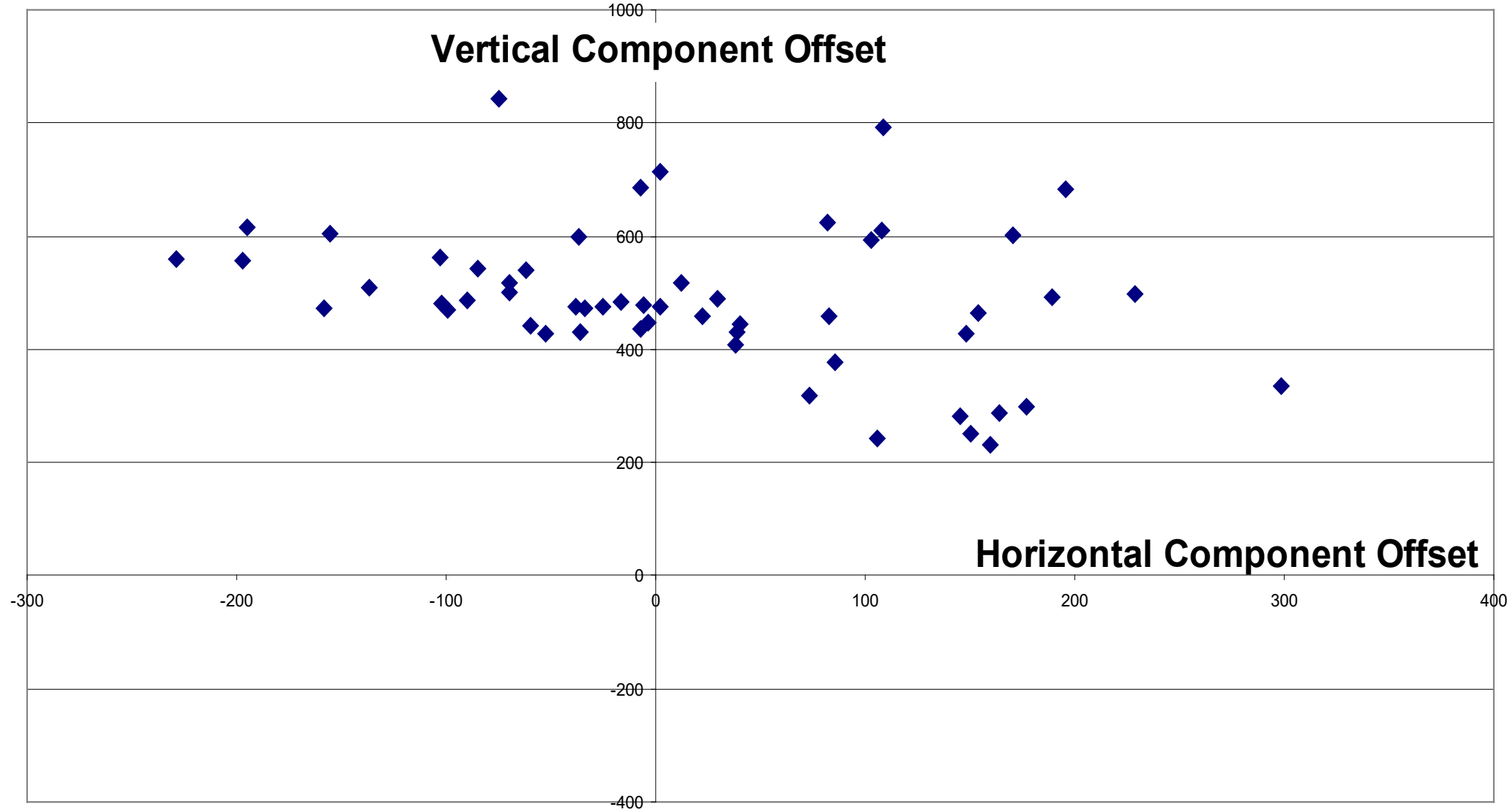
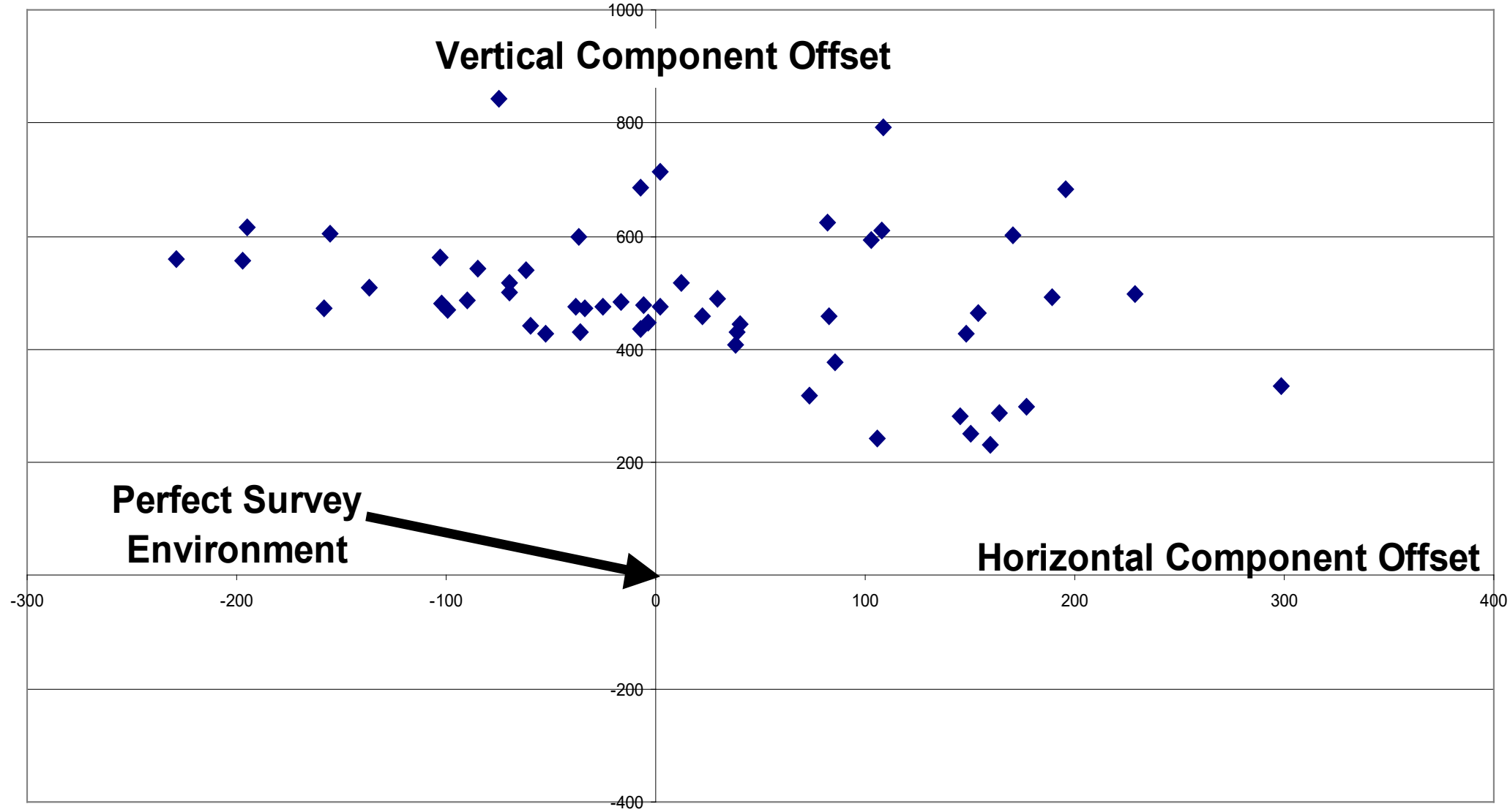
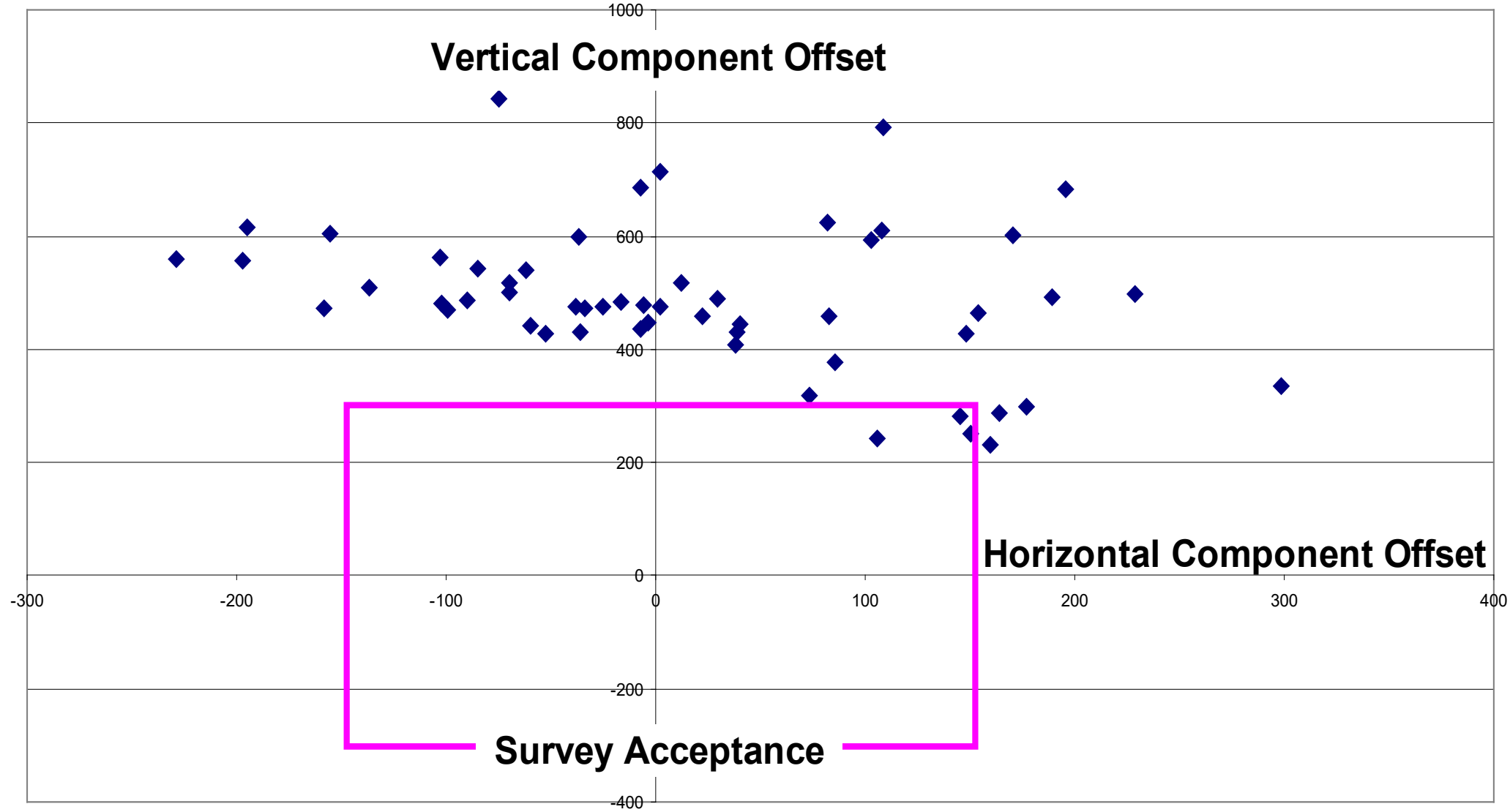
MSA Drillstring Interference Correction



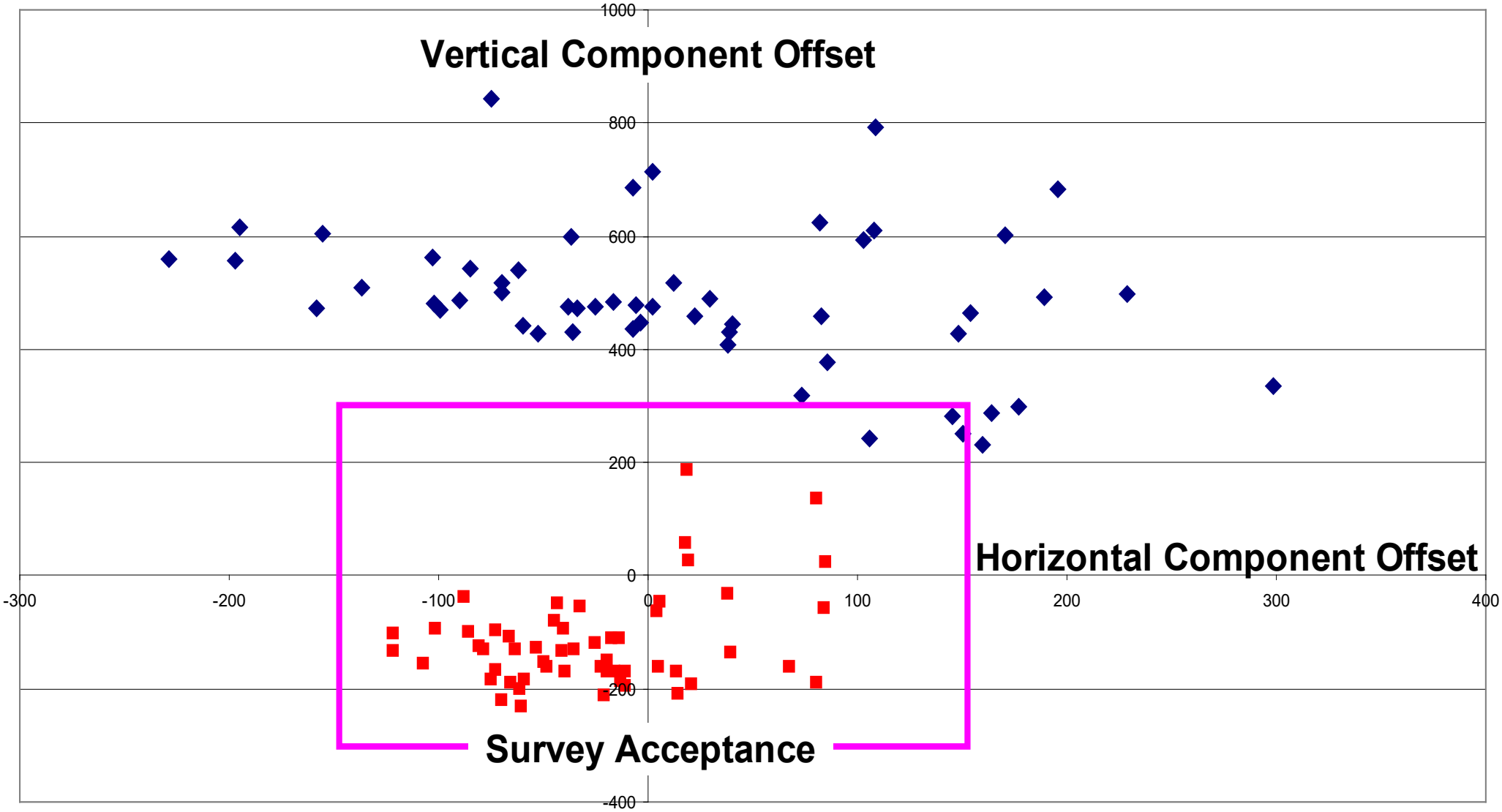
MSA Drillstring Interference Correction



MSA Drillstring Interference Correction

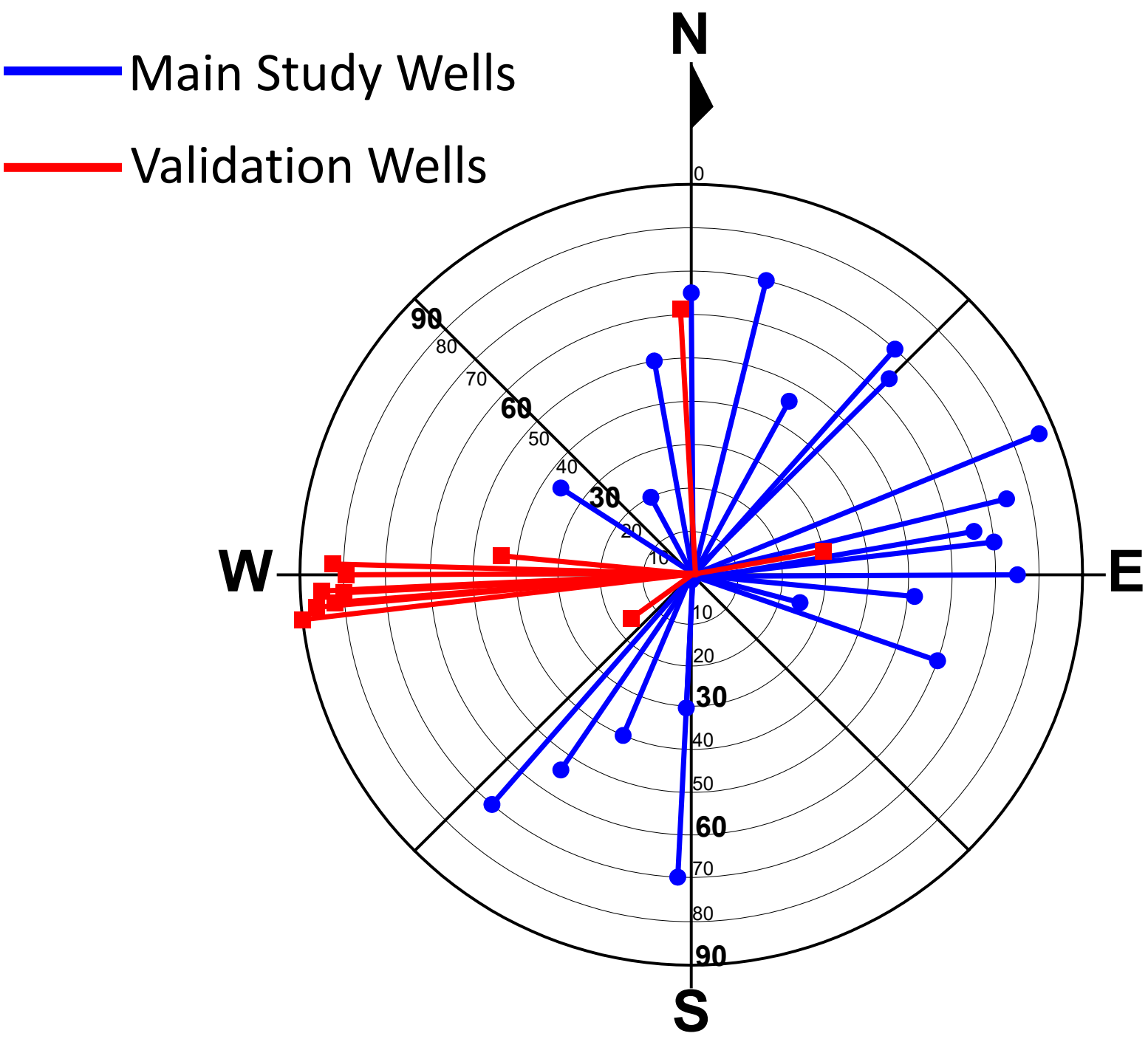


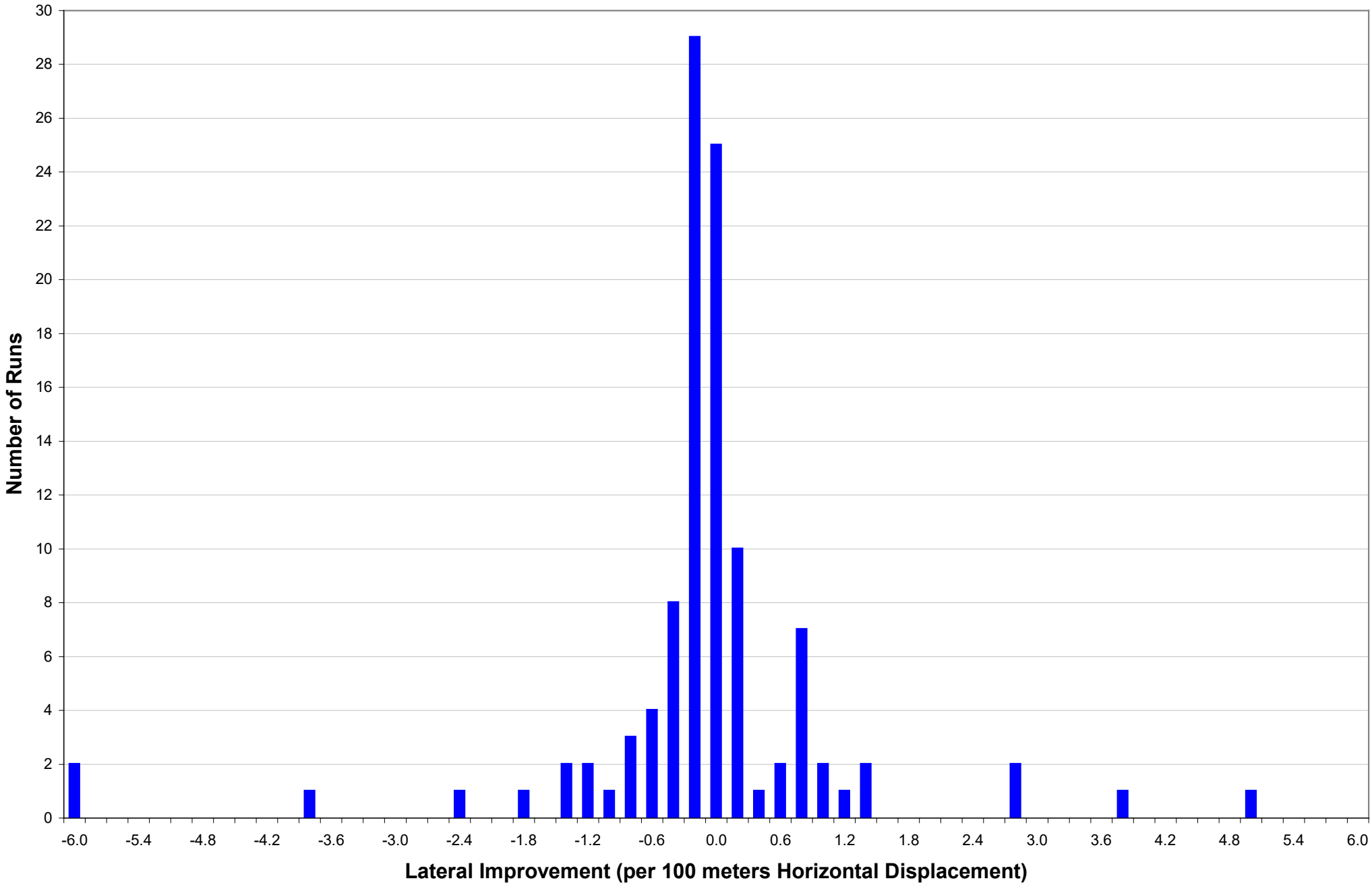
MSA Drillstring Interference Correction



Case Study Data

- Main study - 5 years of drilling data from one field
  - MWD data from 107 BHA runs with good non-mag spacing
  - all with independent overlapping gyro surveys
  - over a range of MWD tool sizes and gyro instrument types.
- Validation wells - 14 BHA runs from worldwide locations
  - 11 wells tough magnetic surveying conditions/orientations,
  - some cases with no nonmag in the BHA except MWD,
  - also all with independent overlapping gyro surveys.
- 121 BHA runs and 758,000ft of MWD & Gyro surveyed hole


Main Study Wells
Validation Wells
N
E
S
W
0
10
20
30
40
50
60
70
80
90


Multistation Analysis Histogram
Number of Runs
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
-6.0
-5.4
-4.8
-4.2
-3.6
-3.0
-2.4
-1.8
-1.2
-0.6
0.0
0.6
1.2
1.8
2.4
3.0
3.6
4.2
4.8
5.4
6.0
Lateral Improvement (per 100 meters Horizontal Displacement)

Average Azimuth Error – Main 68% Runs

$$\text{ISCWSA Azi error} = \sqrt{(D^2 + AMIC^2 + AMID^2 + G^2 + M^2)}$$

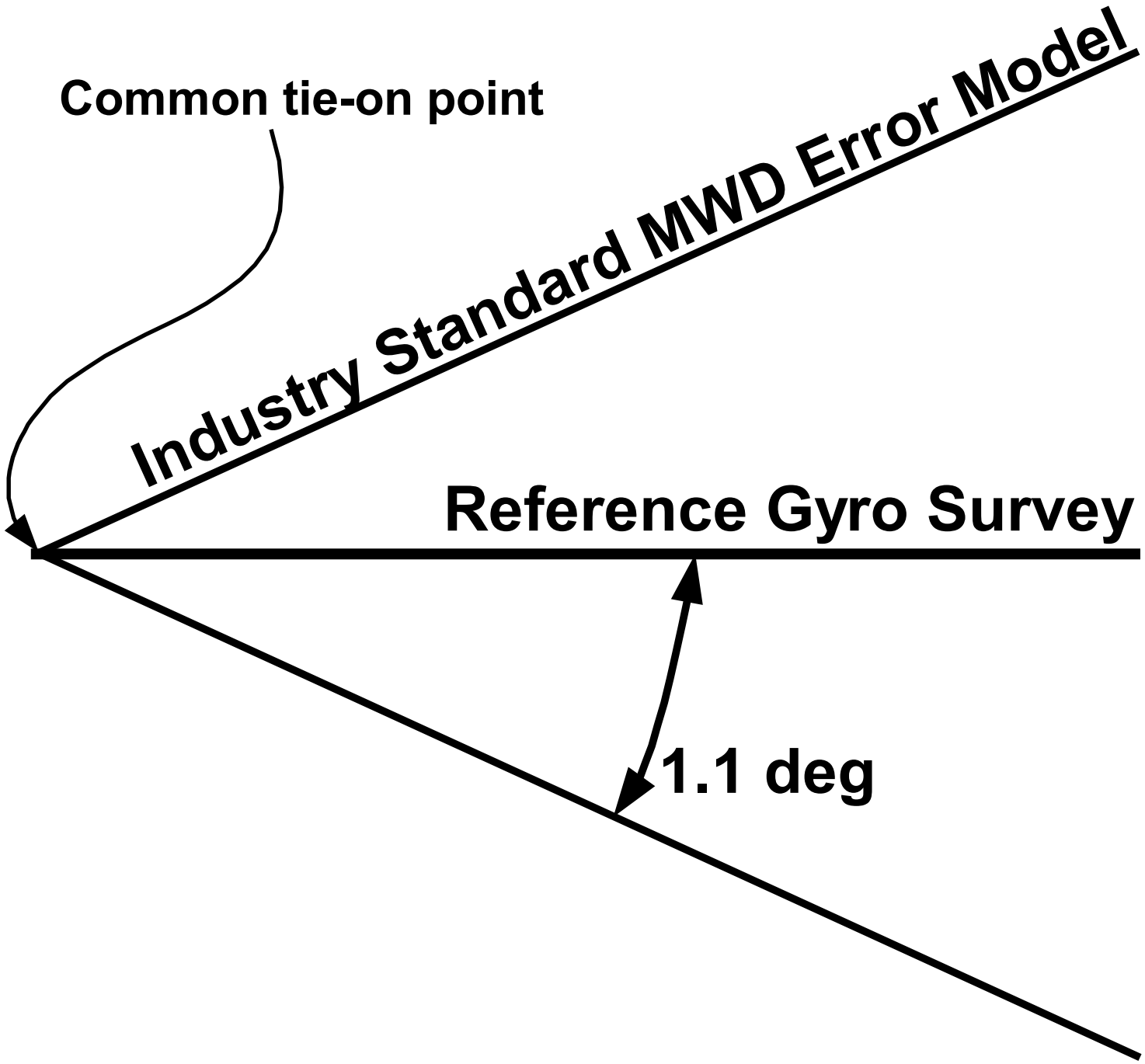
where: D= Declination error (0.49°)

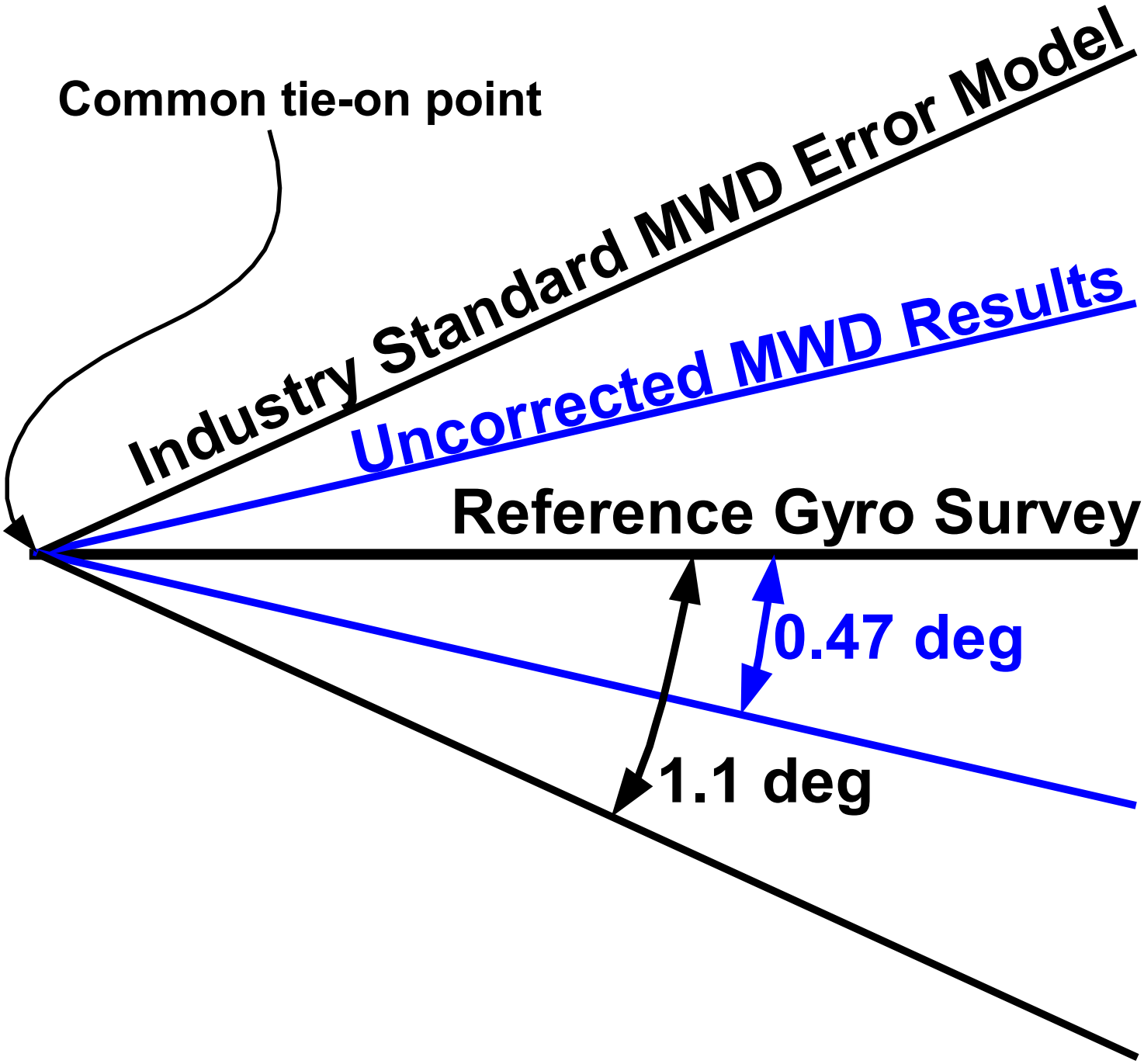
AMIC = Mag-Interference constant (0.25 °)

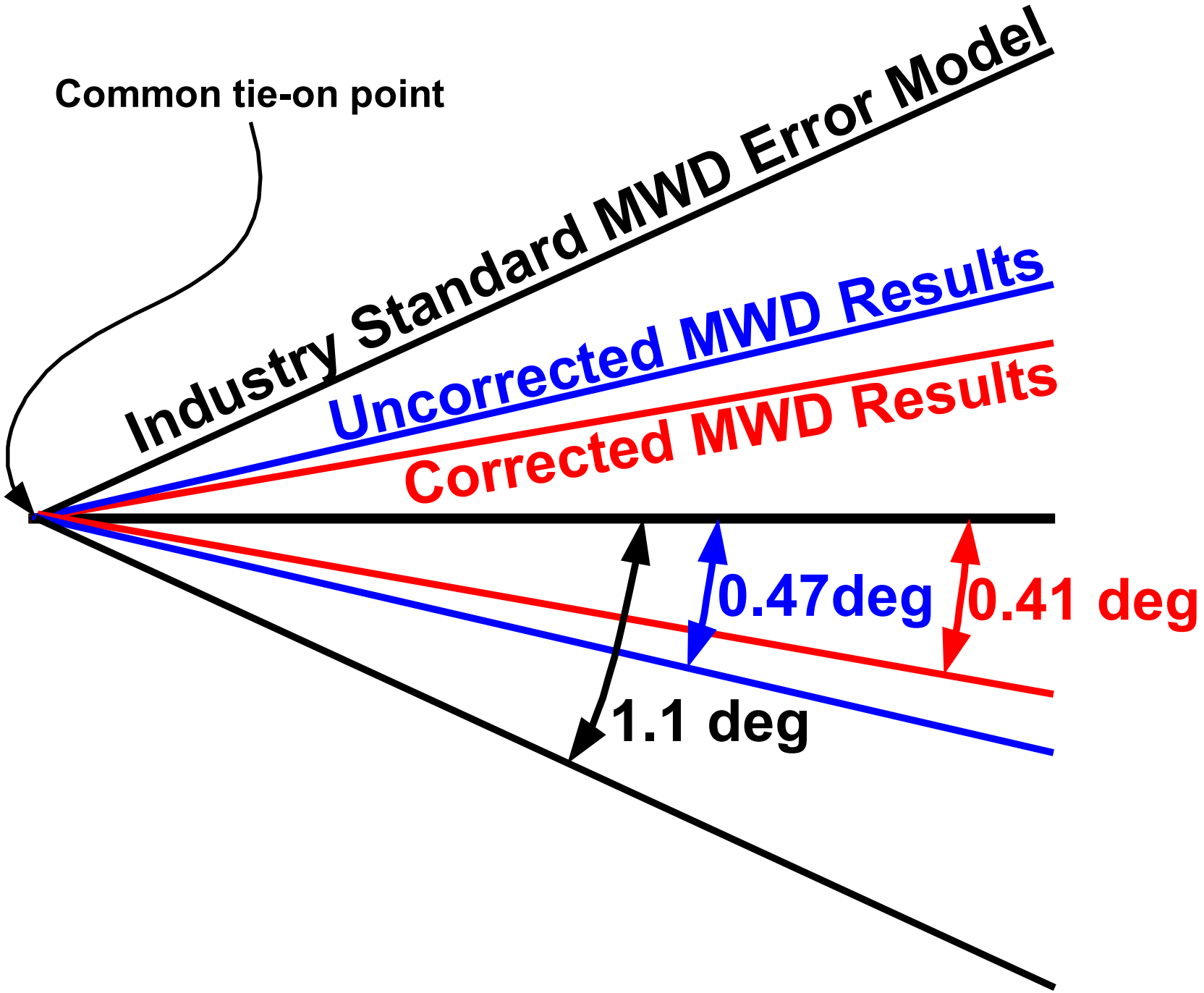
AMID – Mag-Int Direction dependent (0.5 °SinI*SinAz)

G = Gyro sensor error (est 0.33 °)

M = Magnetic sensor error (est 0.44 °CosI/SinI)


Common tie-on point
Industry Standard MWD Error Model
Reference Gyro Survey
1.1 deg


Common tie-on point
Industry Standard MWD Error Model
Uncorrected MWD Results
Reference Gyro Survey
0.47 deg
1.1 deg


Common tie-on point
Industry Standard MWD Error Model
Uncorrected MWD Results
Corrected MWD Results
0.47deg
0.41 deg
1.1 deg

ISCWSA Standard MWD Error Model

MWD-STD	MWD - Standard	
Tool Group	MWD	
Code	Value	Unit
ABX	0.004	m/s^2
ABY	0.004	m/s^2
ABZ	0.004	m/s^2
ASX	0.005	-
ASY	0.005	-
ASZ	0.005	-
MBX	70	nT
MBY	70	nT
MBZ	70	nT
MSX	0.0016	-
MSY	0.0016	-
MSZ	0.0016	-
SAG	0.2	deg
MX	0.06	deg
MY	0.06	deg
AMIC	0.25	deg
AMID	0.5	deg
DECG	0.36	Deg
DBHG	5000	deg-nT
DRFR	0.35	m
DSFS	0.00024	-
DSTB	4.4E-07	/m

MWD Sensor Errors

Sensor Misalignment Errors

Drillstring Magnetic Interference Errors

Magnetic Reference Field Errors

Depth Errors

New AMIC and AMID Coefficients

- To derive new AMIC and AMID terms…
  - First try to estimate new local Declination error term (0.27°)
  - Calculate average angular offset after MSA correction
- This reduced the average azimuth error allowance to 1.0°
  - Still not close to our uncorrected 0.47°
  - ISCWSA may be too conservative in this case - not pursued
  - AMIC for wells with close to zero orientation weighting = 0.15°
  - Average AMID derived to solve equation = 0.3°
- Azimuth bias direction wasn't calculated – (not as modeled?)

Validation of AMIC and AMID Terms

- Average offset in Total |B| = 85nT
- Average offset in Dip angle = 0.15°
- Average offset in Gravity |G| = 0.1mG

Run Num #	Orientation Weighting (sinAz x sinI)	Gyro Major Semi-axis (m)	MSA Major Semi-axis (m)	Horizontal Separation (m)	1-sigma Confidence Overlap (%)
1	-0.9736	29.31	31.89	16.91	72.36
2	-0.9804	60.92	52.46	4.69	95.87
3	-0.5104	28.07	36.13	30.86	51.94
4	-0.9749	44.08	43.48	59.58	31.95
5	-0.9811	56.26	48.49	28.8	72.51
6	-0.9821	61.1	54.75	41.63	64.06
7	-0.9752	48.45	47.74	6.76	92.97
8	-0.9867	70.37	58.97	4	96.91
9	0.0284	20.54	20.62	2.13	94.82
10	0.1984	20.54	21.14	2.27	94.54
11	-0.6694	25.23	30.69	2.52	95.49
12	-0.0321	20.44	20.55	0.76	98.13
13	-0.1346	21.69	25.11	4.15	91.14
14	-0.1057	27.28	26.29	4.18	92.2