Appendix F: Accelerations

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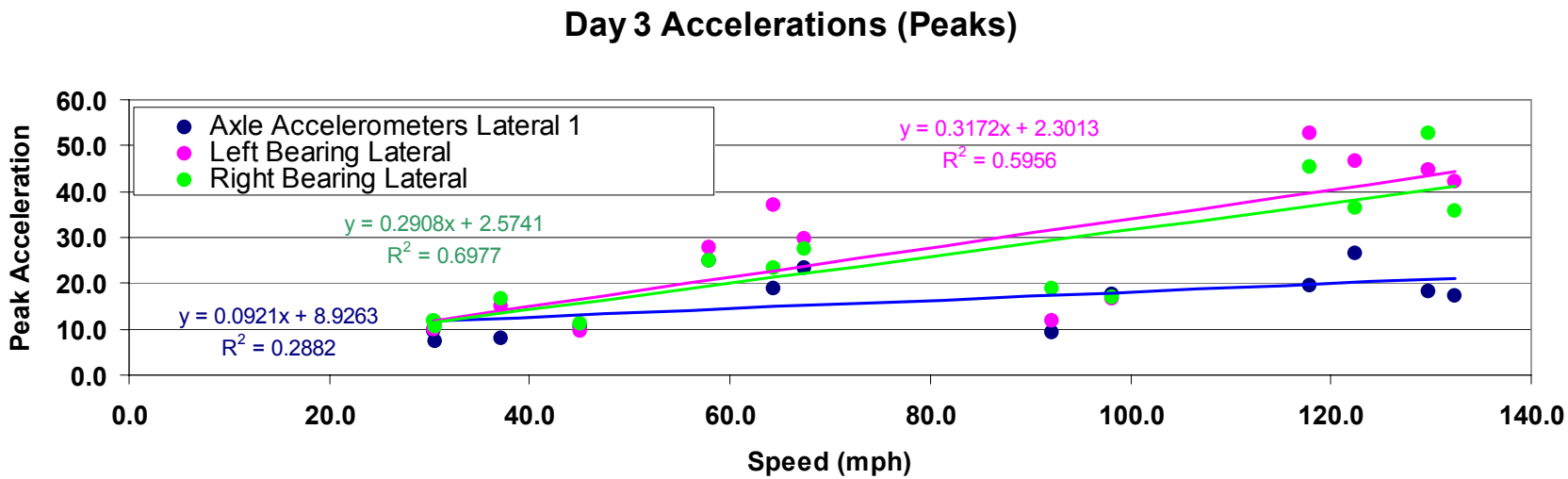
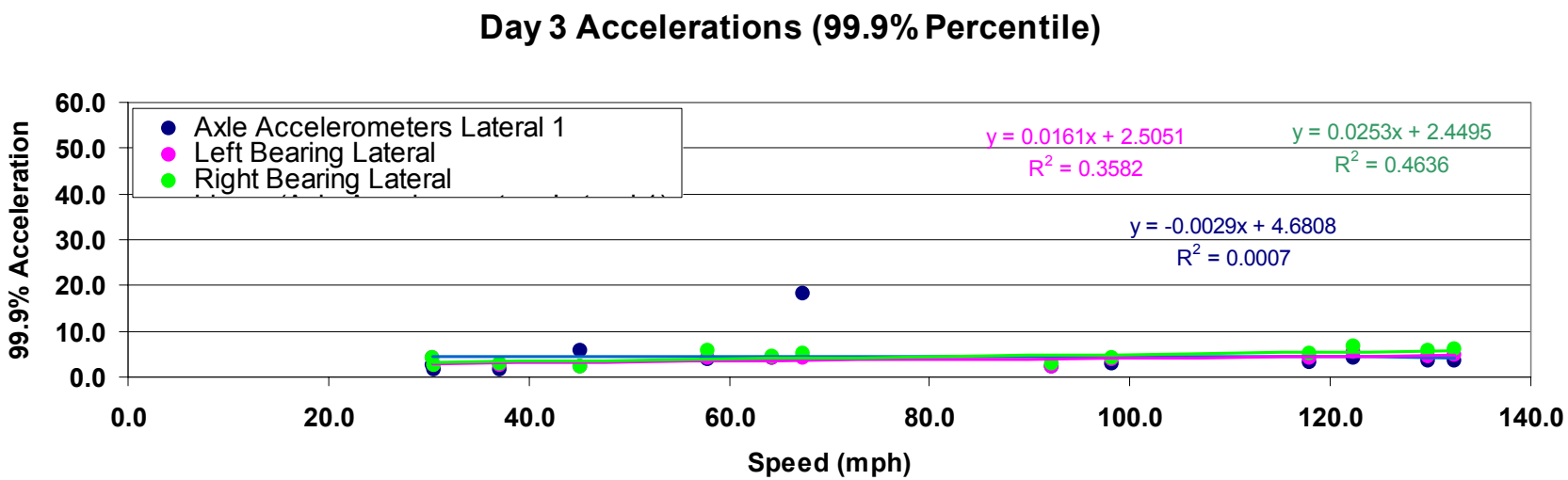
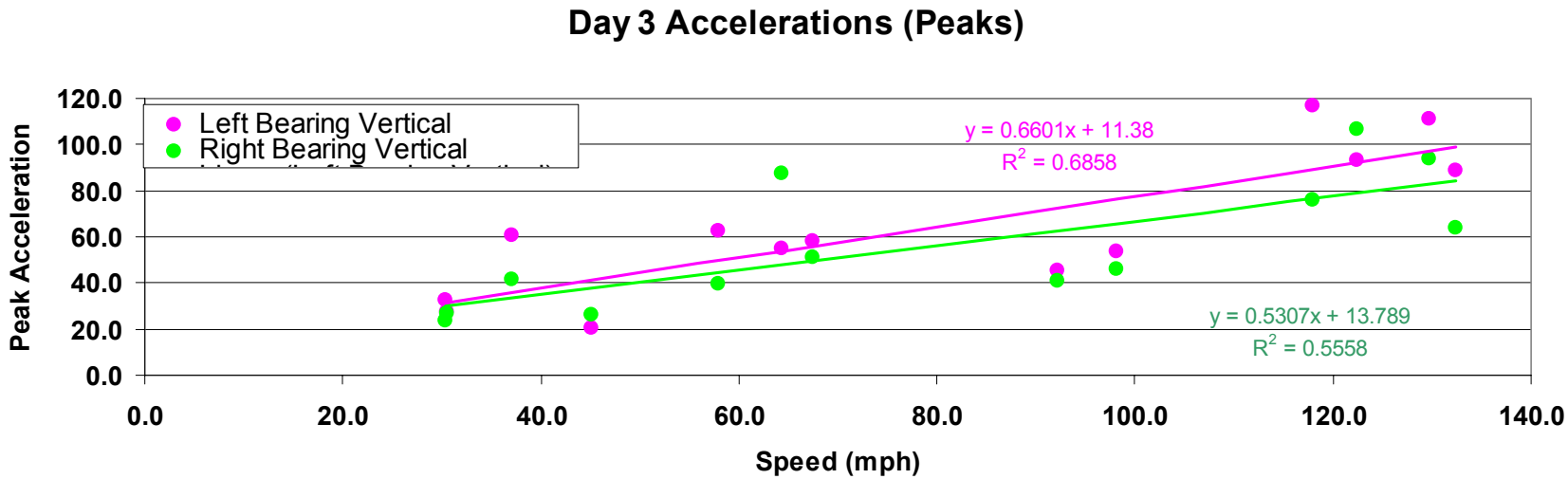
Axle Accelerations

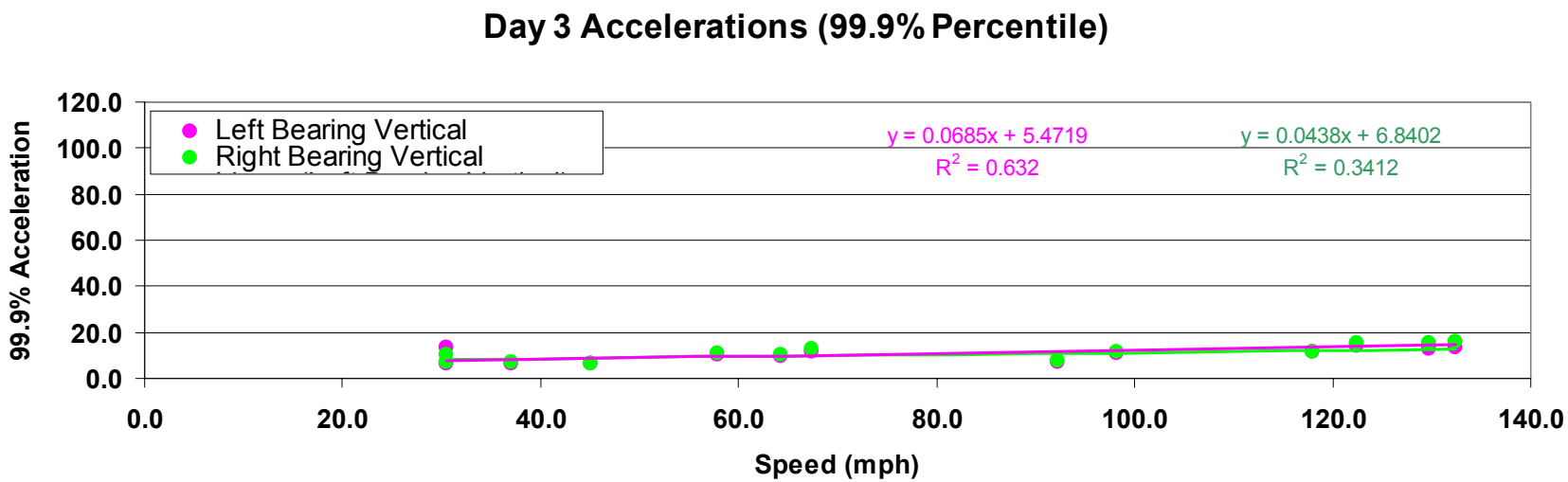
Lateral Acceleration (Lead)





Vertical Acceleration (Lead)

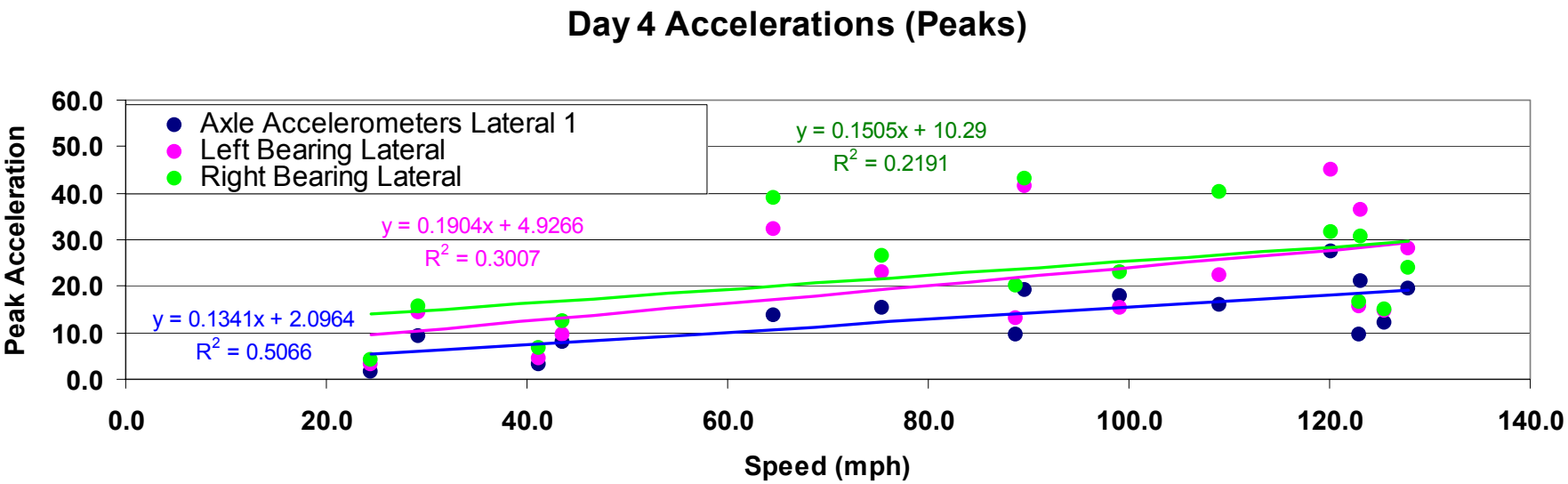


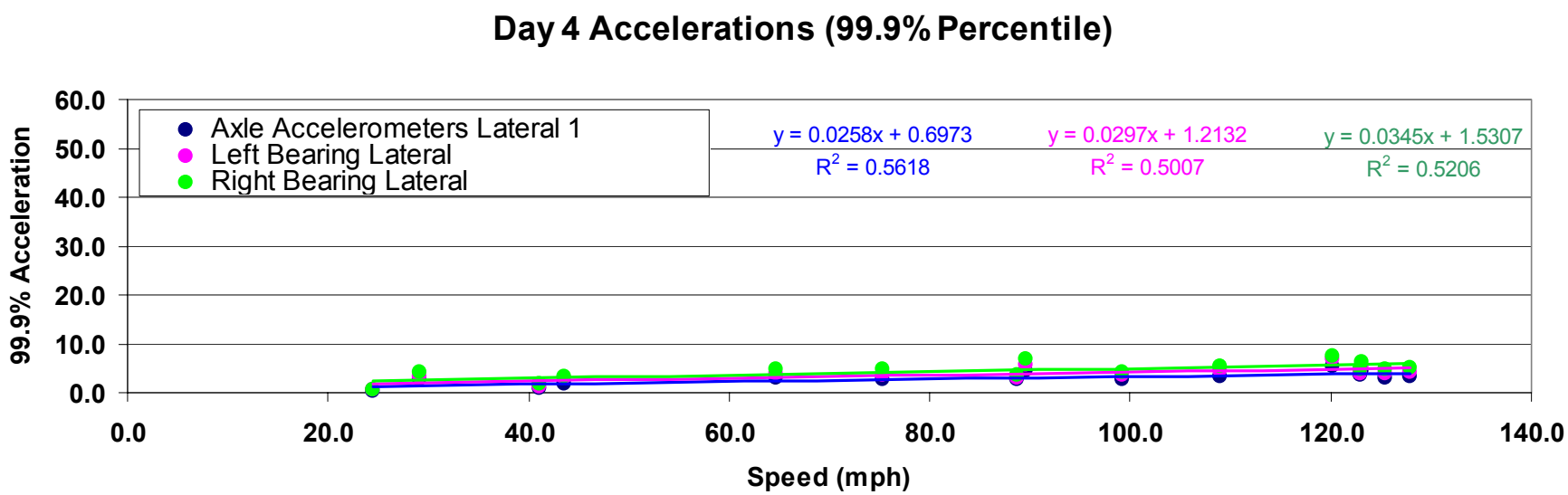


Conclusions – 5/26/05

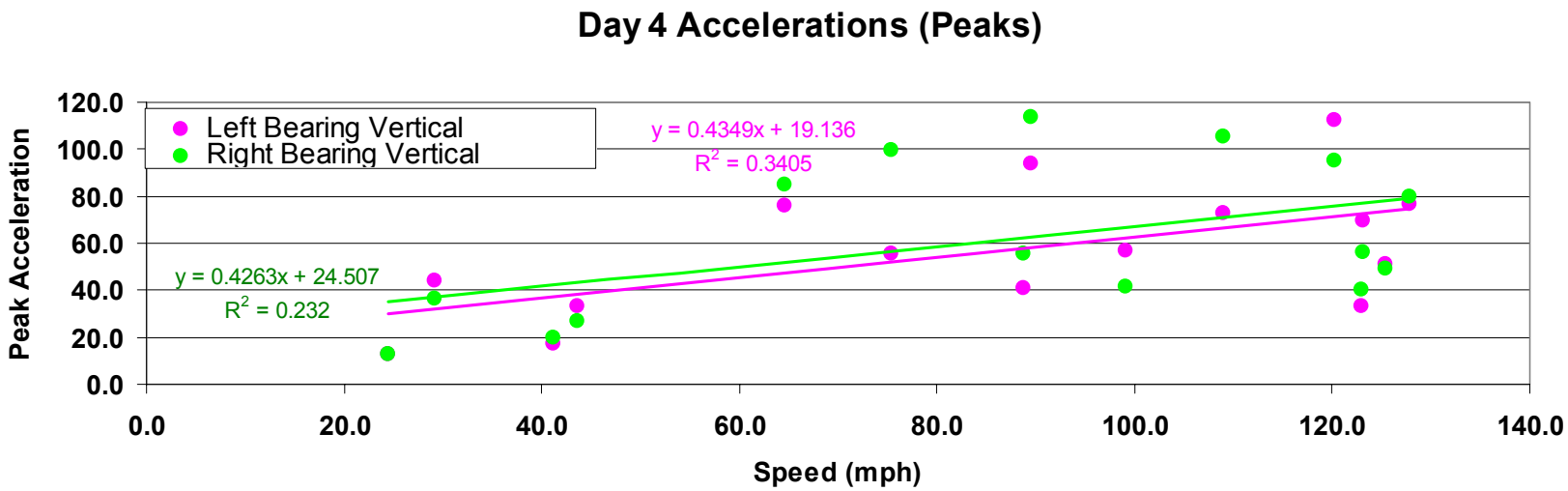
- The car tested with the instrumented axle in the leading position
- Accelerations Generally Increase With Speed
- Lateral Acceleration Measured On The Bearing Generally Higher Than On The Axle
- Axle Bearing System Peak Accelerations
  - Vertical Bearing – 117 G's
  - Lateral Bearing – 53 G's
  - Lateral Axle – 26 G's

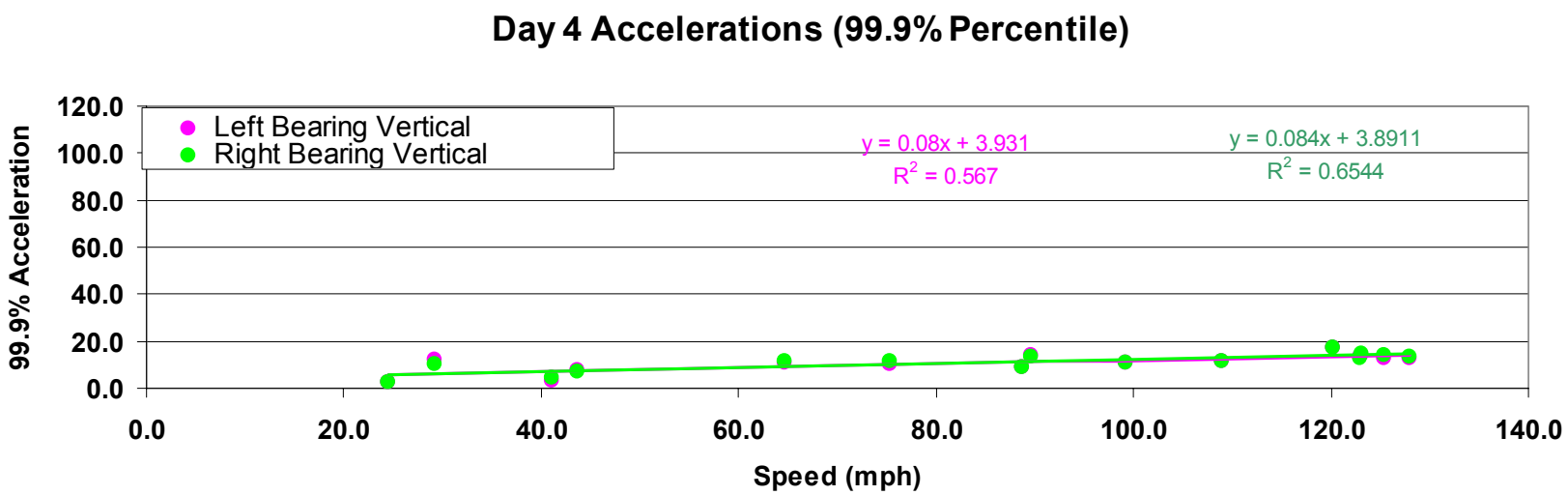
Lateral Acceleration (Trailing)





Vertical Acceleration (Trailing)

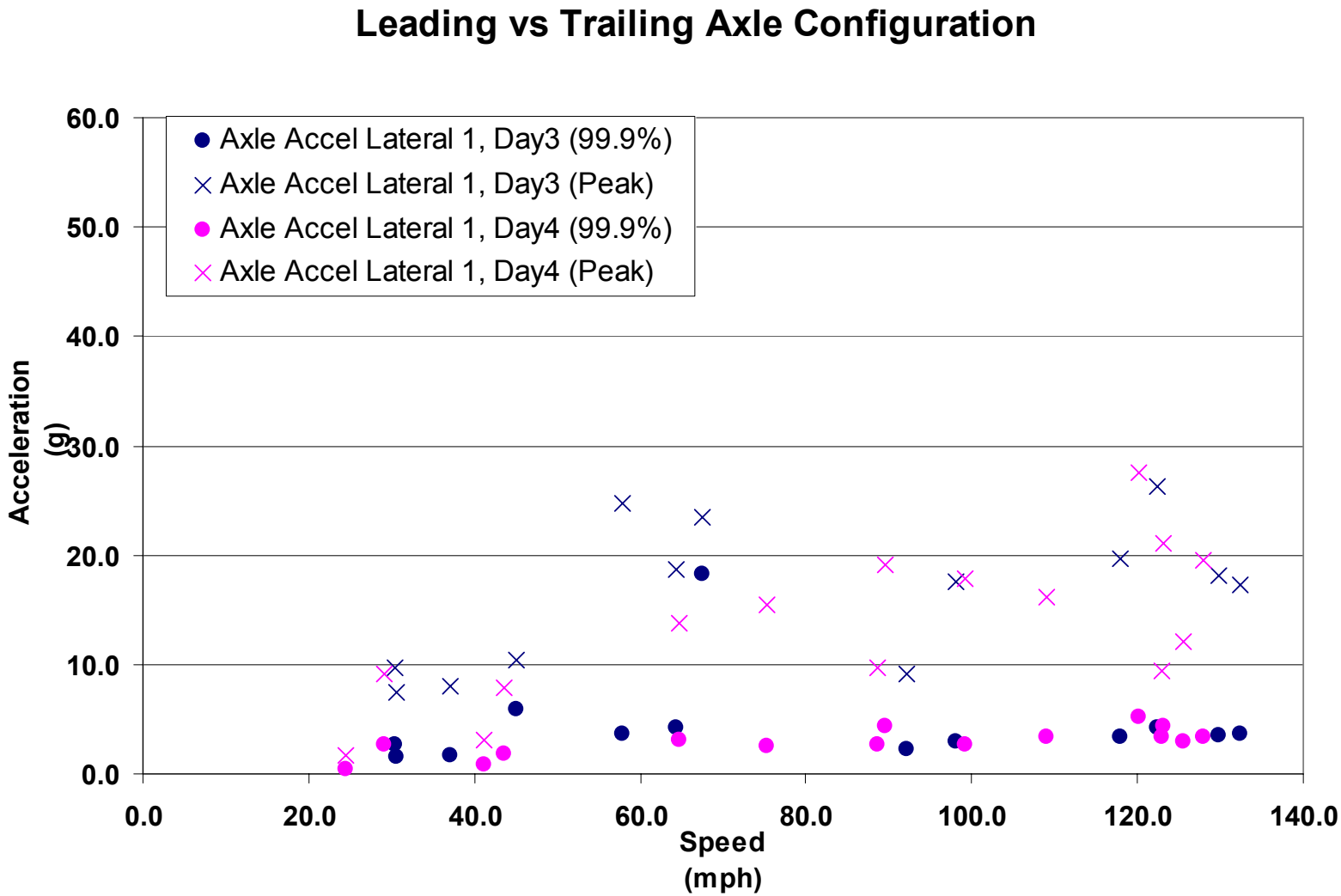




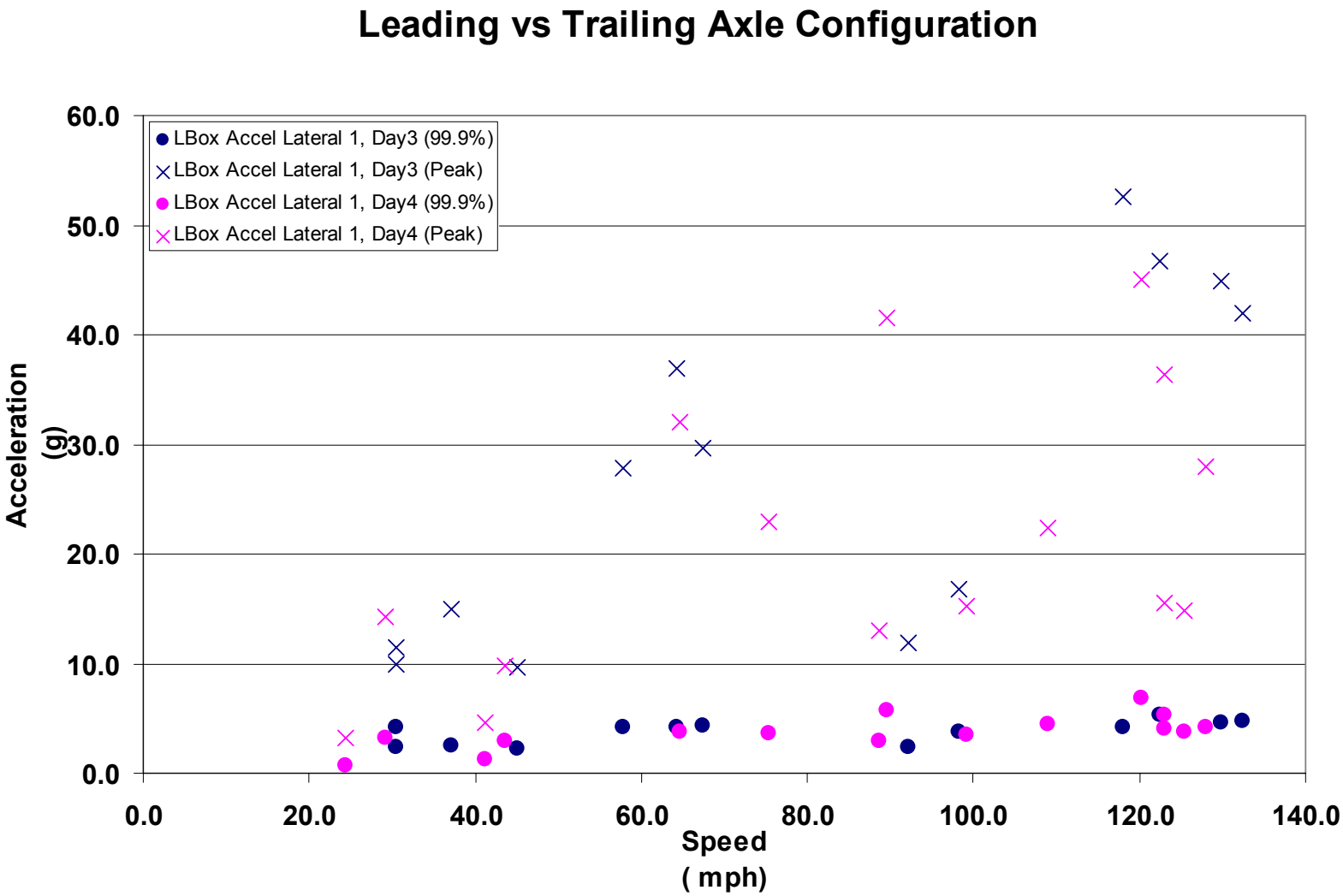
Conclusions – 5/27/05

- The car tested with the instrumented axle in the trailing position
- Accelerations Generally Increase With Speed
- Lateral Acceleration Measured On The Bearing Generally Higher Than On The Axle
- Axle Bearing System Peak Accelerations
  - Vertical– 113 G's
  - Lateral Bearing– 45 G's
  - Lateral Axle – 26 G's

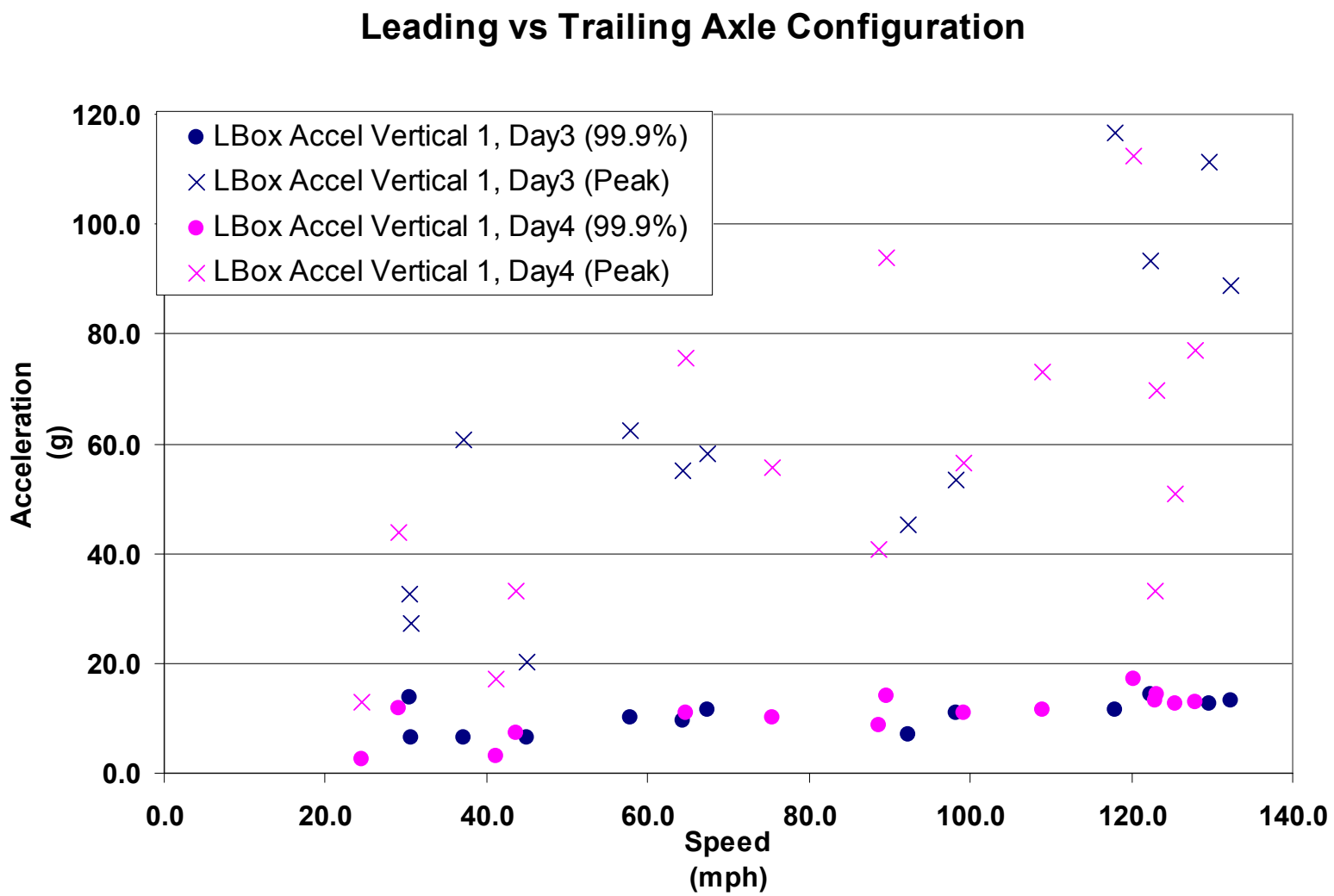
Axle Lateral, Leading vs Trailing



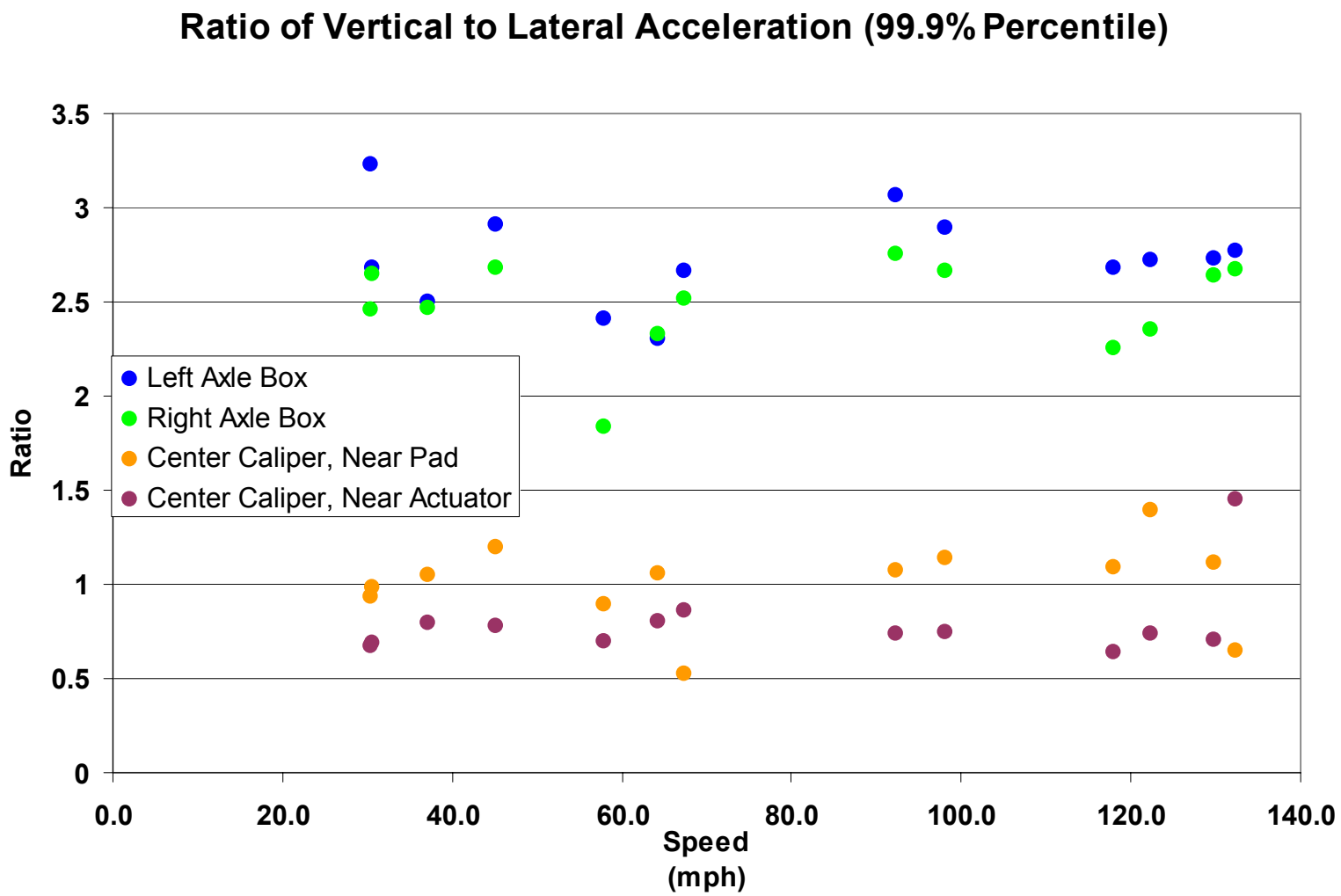
LBox Lateral, Leading vs Trailing



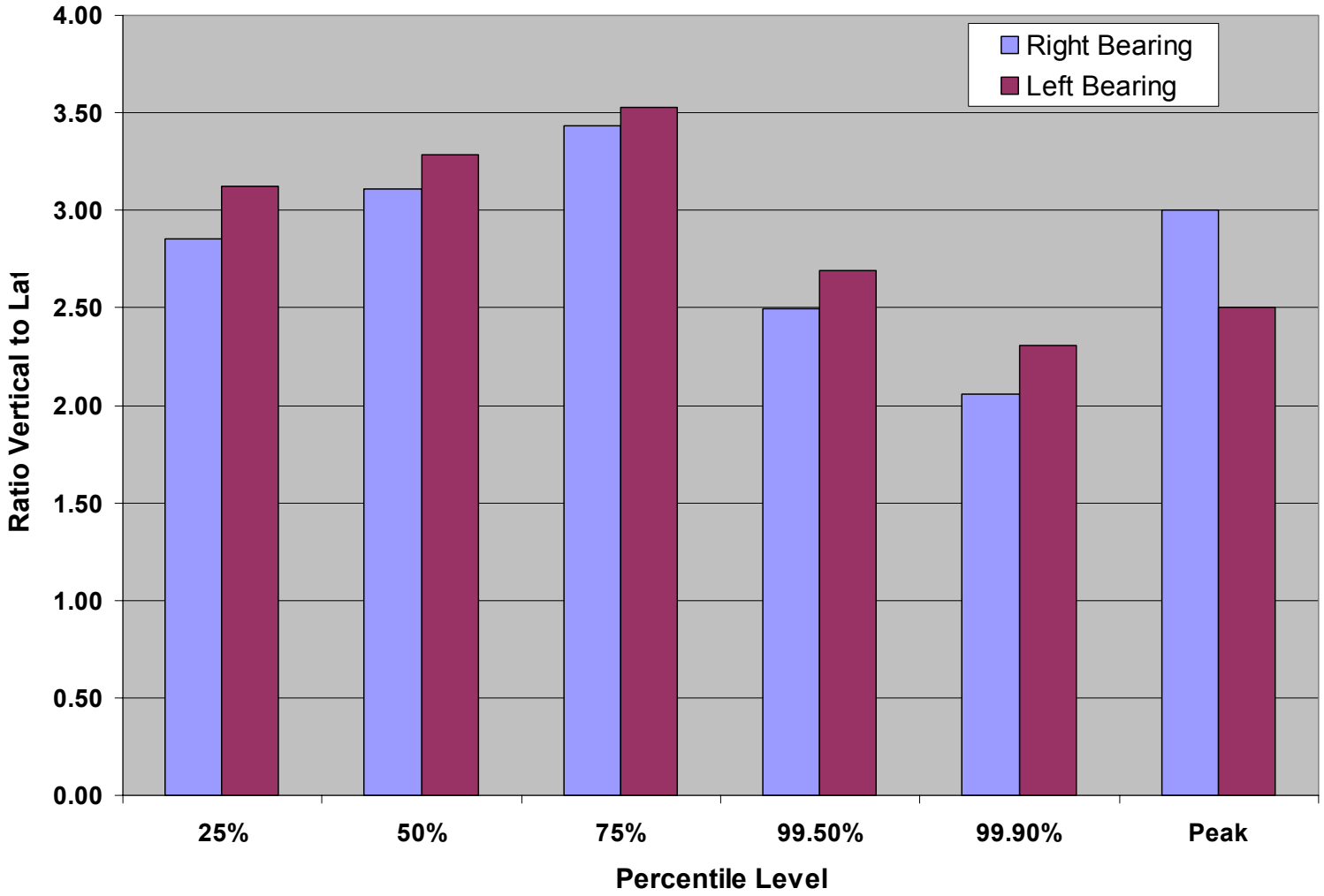
LBox Vertical, Leading vs Trailing



Vertical to Lateral Ratio



Vertical to Lateral Ratio



Other Observations

- Change in accelerations due to axle position as leading or trailing is negligible
- Vertical Accelerations on Bearing Boxes 2 To 3.5 Times the Lateral Accelerations
- Vertical Accelerations on Calipers 0.5 to 1.5 times the Lateral Accelerations

Lateral Shocks

Table F.1 Lateral Accelerations Exceeding 30 G

Acceleration Range	May 16, 2005 Washington, DC, to Boston, MA Test Axle in Trail Position			May 17, 2005 Boston, MA, to Washington, DC Test Axle in Lead Position		
	W/S-W Left	W/S-W Right	W/S-W Axle	W/S-W Left	W/S-W Right	W/S-W Axle
30 g ≤ x < 40 g	0	2	0	0	4	0
40 g ≤ x < 50 g	0	0	0	0	0	0
50 g ≤ x < 60 g	0	0	0	0	0	0
60 g ≤ x < 70 g	0	0	0	0	0	0
70 g ≤ x < 80 g	0	0	0	0	0	0
80 g ≤ x	0	0	0	0	0	0
Total	0	2	0	0	4	0
Maximum	0	37.34	0	0	39.1	0
Minimum	0	37.05	0	0	32.07	0

Acceleration Range	May 26, 2005 Washington, DC, to Boston, MA Test Axle in Lead Position			May 27, 2005 Boston, MA, to Washington, DC Test Axle in Trail Position		
	W/S-W Left	W/S-W Right	W/S-W Axle	W/S-W Left	W/S-W Right	W/S-W Axle
30 g ≤ x < 40 g	22	8	0	12	6	0
40 g ≤ x < 50 g	6	3	0	6	4	0
50 g ≤ x < 60 g	2	2	0	0	2	0
60 g ≤ x < 70 g	0	0	0	1	2	0
70 g ≤ x < 80 g	1	0	0	0	0	0
80 g ≤ x	0	0	0	0	0	0
Total	31	13	0	19	14	0
Maximum	75.33	52.65	0	62.46	38.56	0
Minimum	30.04	-52.45	0	-44.97	-63.74	0

Represents the number of acceleration events where the lateral acceleration on the axle boxes exceeded 30 G.
The Right Box accelerometers were changed from the Silicon Design accelerometers to PCB accelerometers after Day 2.

Table F.1 Lateral Accelerations Exceeding 30 G

Acceleration Range	June 17, 2005 Washington, DC, to Boston, MA Test Axle in Lead Position					
	W/S-W Left	W/S-W Right	W/S-W Axle	Knorr Left	Knorr Right	Knorr Axle
30 g ≤ x < 40 g	15	8	0	15	10	0
40 g ≤ x < 50 g	2	1	0	3	0	0
50 g ≤ x < 60 g	1	1	0	1	0	0
60 g ≤ x < 70 g	0	0	0	0	0	0
70 g ≤ x < 80 g	0	0	0	0	0	0
80 g ≤ x	0	0	0	0	0	0
Total	18	10	0	19	10	0
Maximum	58.53	38.91	0	44.56	38.92	0
Minimum	-38.29	-51.37	0	-58.38	30.16	0

Acceleration Range	June 18, 2005 Boston, MA, to Washington, DC Test Axle in Lead Position					
	W/S-W Left	W/S-W Right	W/S-W Axle	Knorr Left	Knorr Right	Knorr Axle
30 g ≤ x < 40 g	8	8	0	6	7	0
40 g ≤ x < 50 g	6	1	0	0	1	0
50 g ≤ x < 60 g	2	0	0	0	0	0
60 g ≤ x < 70 g	0	0	0	0	0	0
70 g ≤ x < 80 g	0	0	0	0	0	0
80 g ≤ x	0	0	0	0	0	0
Total	16	9	0	6	8	0
Maximum	52.98	42.96	0	38.63	41.3	0
Minimum	30.52	30.78	0	-30.95	30.36	0

Represents the number of acceleration events where the lateral acceleration on the axle boxes exceeded 30 G.
The Right Box accelerometers were changed from the Silicon Design accelerometers to PCB accelerometers after Day 2.

Vertical Shocks

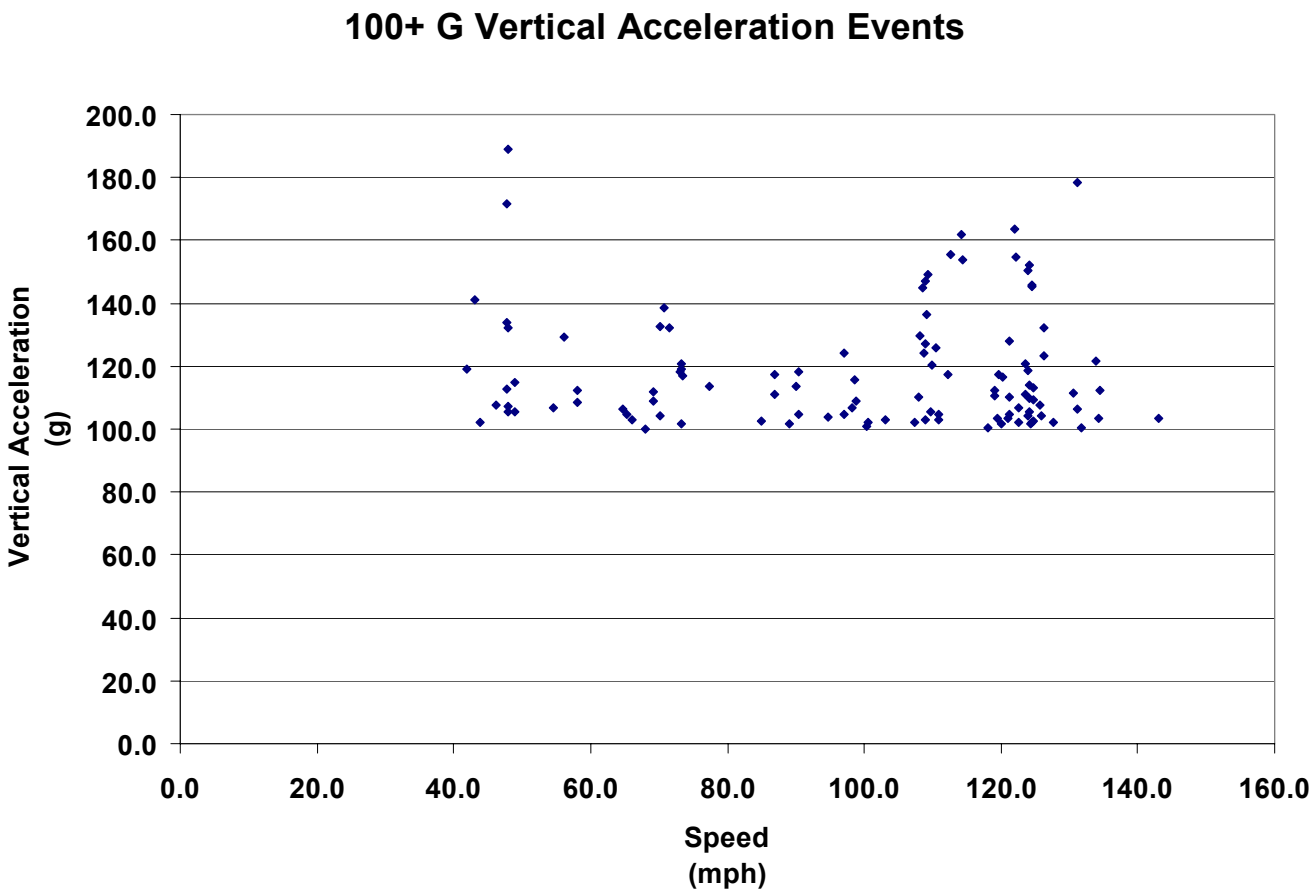
Table F.2 Vertical Accelerations Exceeding 50 G

Acceleration Range	May 16, 2005 Washington, DC, to Boston, MA Test Axle in Trail Position		May 17, 2005 Boston, MA, to Washington, DC Test Axle in Lead Position		May 26, 2005 Washington, DC, to Boston, MA Test Axle in Lead Position		May 27, 2005 Boston, MA, to Washington, DC Test Axle in Trail Position	
	W/S-W Left	W/S-W Right	W/S-W Left	W/S-W Right	W/S-W Left	W/S-W Right	W/S-W Left	W/S-W Right
50 g ≤ x < 60 g	45	42	34	38	58	74	45	55
60 g ≤ x < 70 g	13	23	16	20	29	39	19	31
70 g ≤ x < 80 g	18	6	8	7	11	16	17	24
80 g ≤ x < 90 g	6	3	9	5	6	14	7	10
90 g ≤ x < 100 g	5	6	4	12	5	8	8	7
100 g ≤ x	5	0	8	0	6	10	5	10
Total	92	80	79	82	115	161	101	137
Maximum	126.05	99.08	117.52	99.18	155.58	145	132.28	132.25
Minimum	-61.05	-52.97	-51.3	-69.67	-69.4	-52.02	-57.3	-69.54

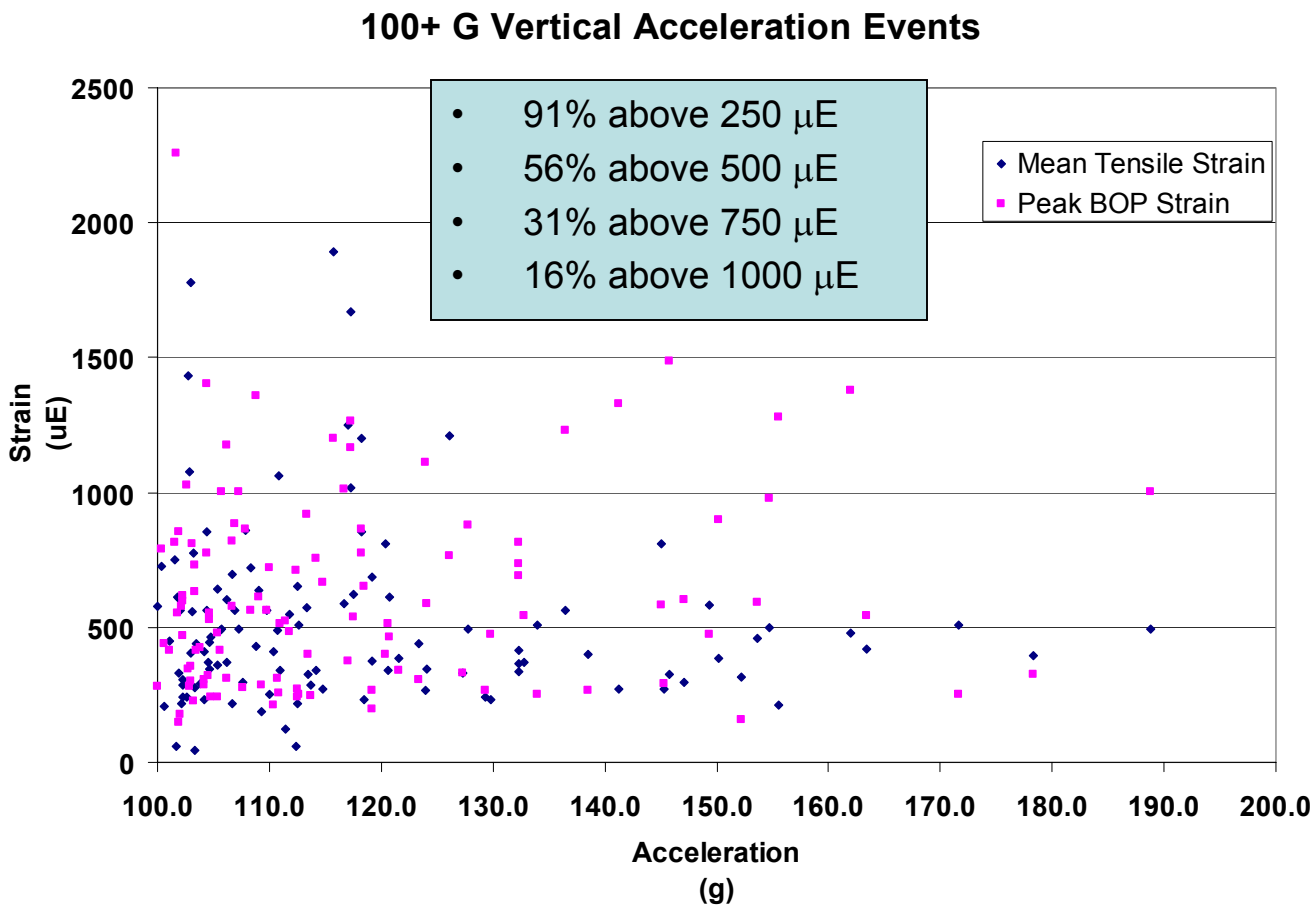
Acceleration Range	June 17, 2005 Washington, DC, to Boston, MA Test Axle in Lead Position				June 18, 2005 Boston, MA, to Washington, DC Test Axle in Lead Position			
	W/S-W Left	W/S-W Right	Knorr Left	Knorr Right	W/S-W Left	W/S-W Right	Knorr Left	Knorr Right
50 g ≤ x < 60 g	35	50	36	37	36	30	37	32
60 g ≤ x < 70 g	25	26	24	18	18	21	20	23
70 g ≤ x < 80 g	17	13	10	23	6	8	12	13
80 g ≤ x < 90 g	7	9	5	7	8	10	6	6
90 g ≤ x < 100 g	3	5	10	2	2	6	1	2
100 g ≤ x	9	7	13	8	8	6	11	6
Total	96	110	98	95	78	81	87	82
Maximum	188.85	150.23	171.58	152.25	154.69	132.34	178.27	123.41
Minimum	50.02	50.35	50.03	50.03	50.31	50.07	50.61	50.13

Represents the number of acceleration events where the vertical acceleration on the axle boxes exceeded 50 G.
The Right Box accelerometers were changed from the Silicon Design accelerometers to PCB accelerometers after Day 2.

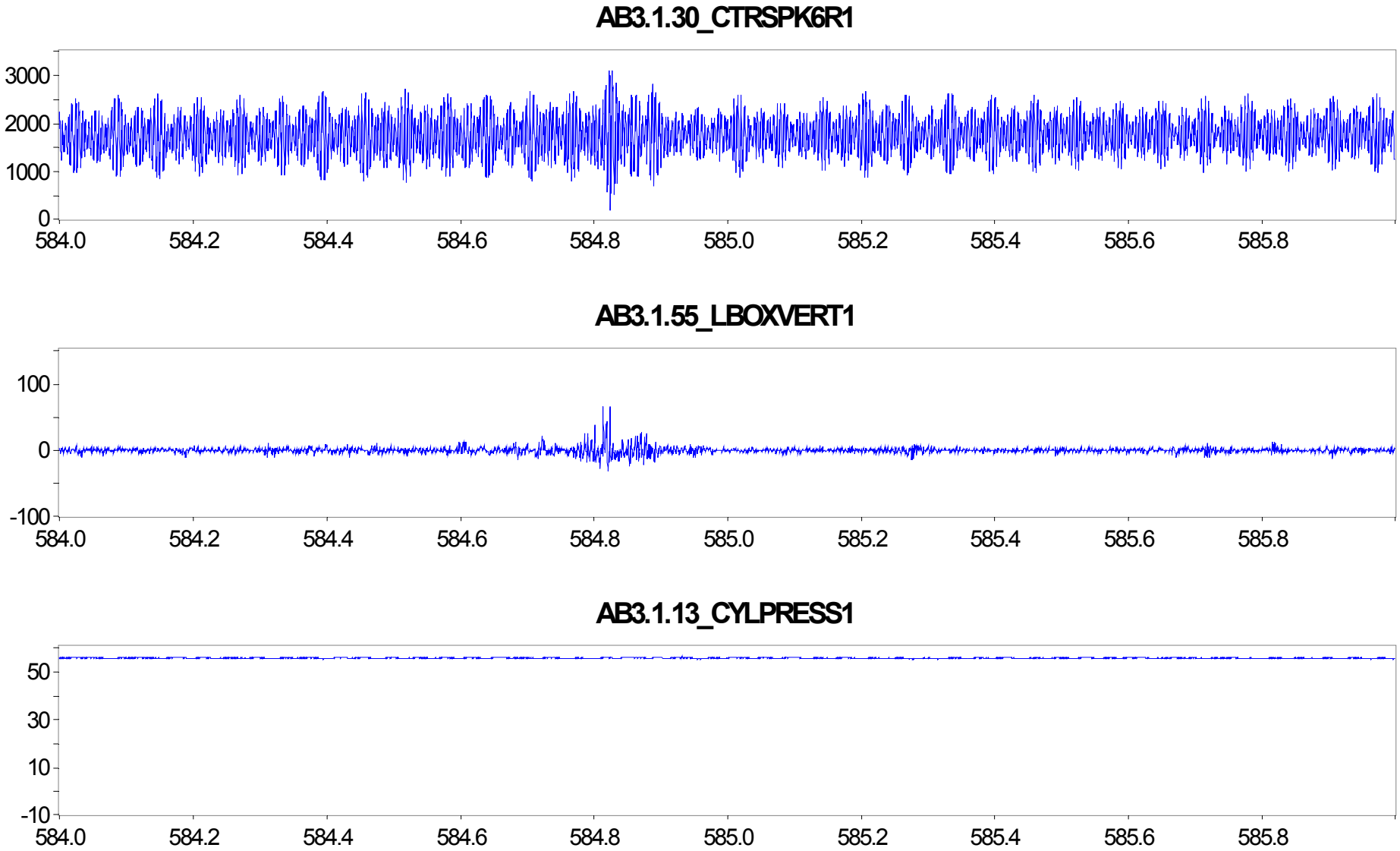
Vertical Accelerations Exceeding 100 G vs. Speed



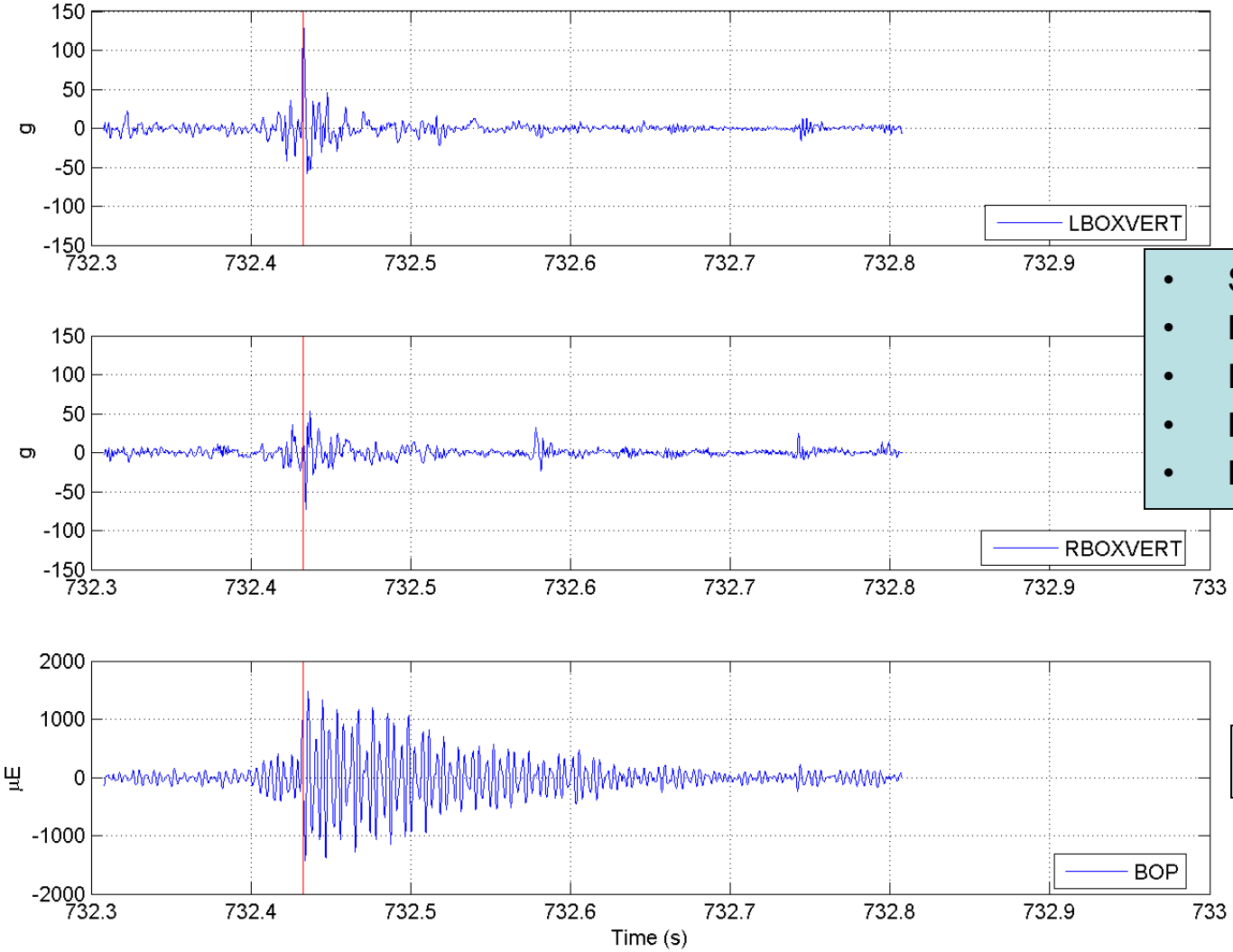
BOP vs Vertical Acceleration



Vertical Impulse During Sustained Oscillations



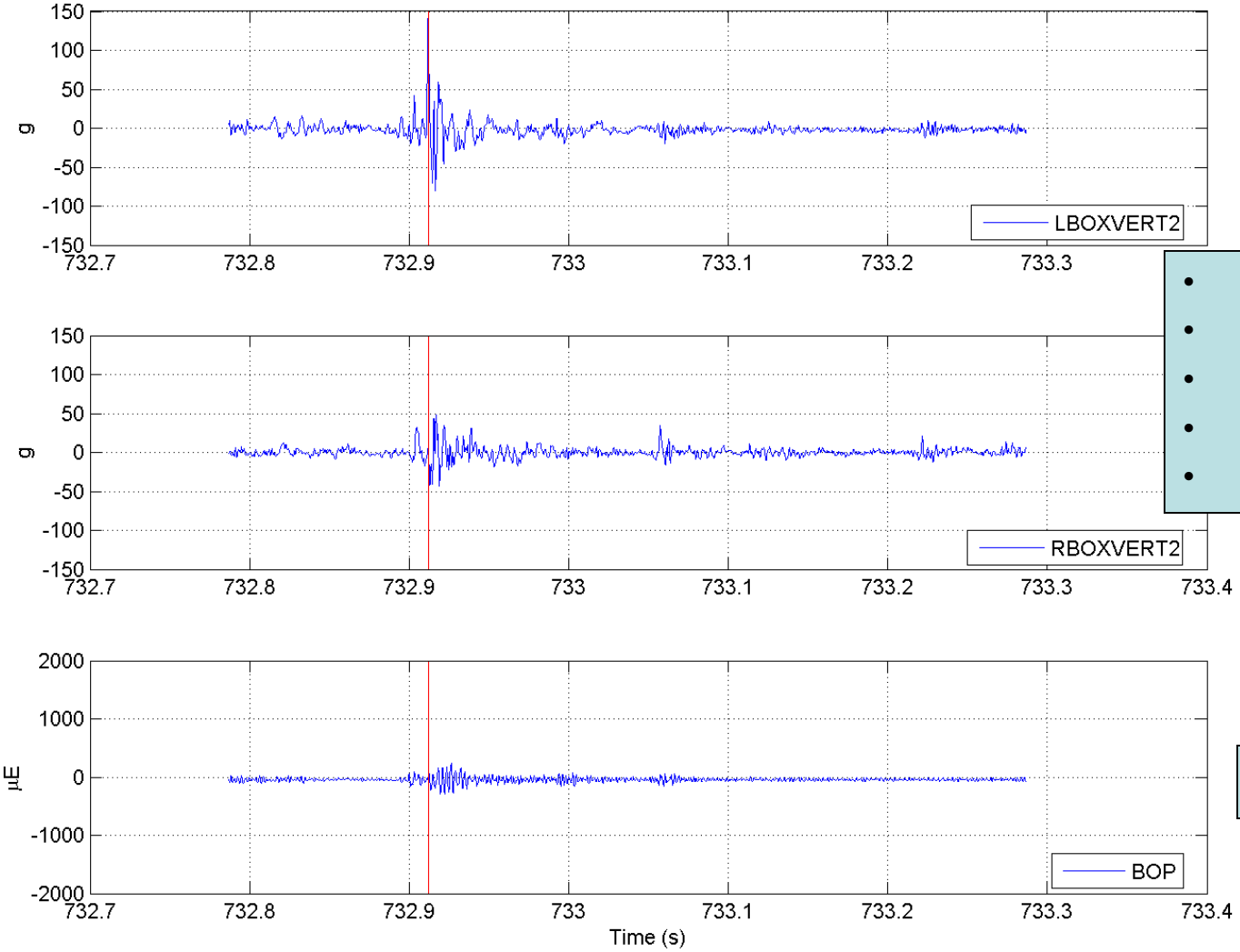
WABTEC/SAB-WABCO Disc



- Speed = 124.5 mph
- LBOXVERT = 145.75 g
- RBOXVERT = -73.05 g
- BOP = 1487 μE
- Brake Pressure = 0.439 psi

Day 7 (6/18/2005) – File 30

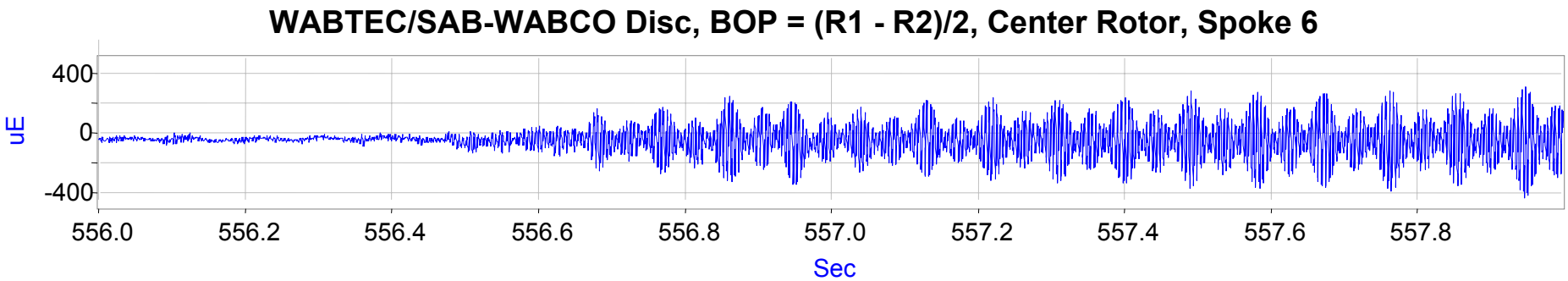
Knorr Disc

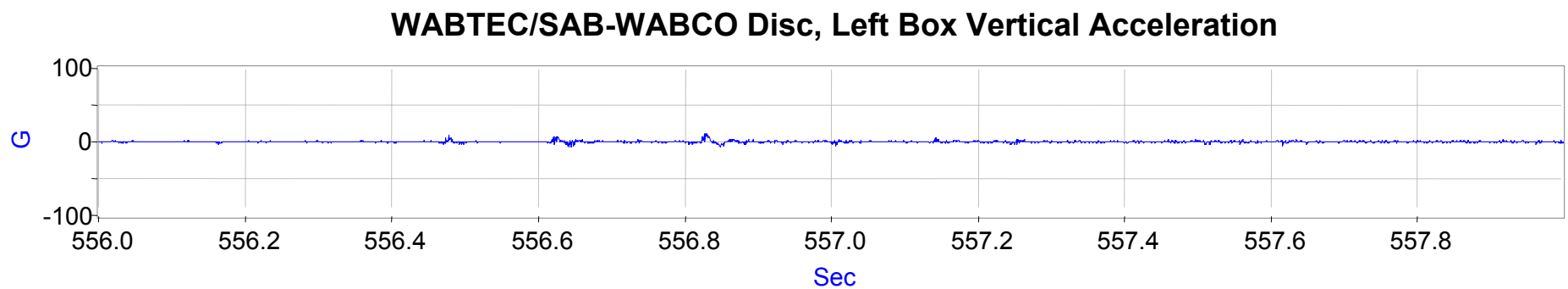


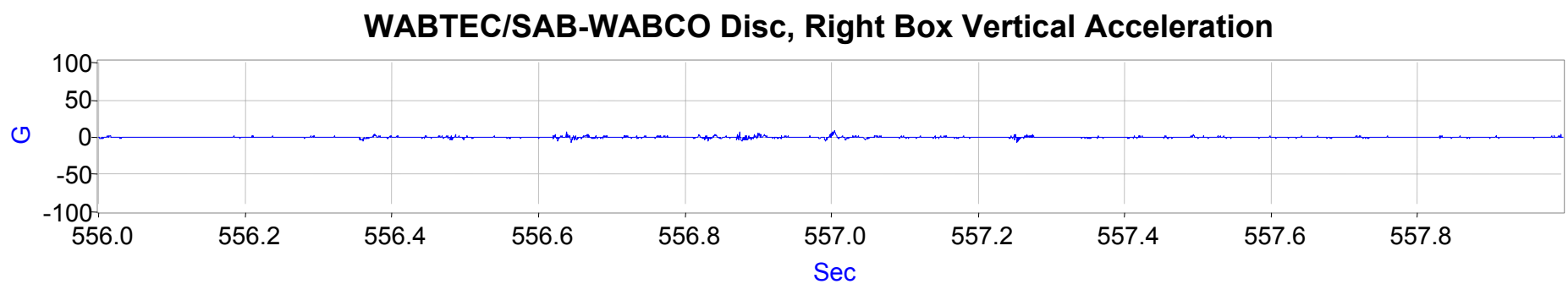
- Speed = 124.5 mph
- LBOXVERT = 145.29 g
- RBOXVERT = -48.61 g
- BOP = 290 μE
- Brake Pressure = 0.25 psi

Day 7 (6/18/2005) – File 30

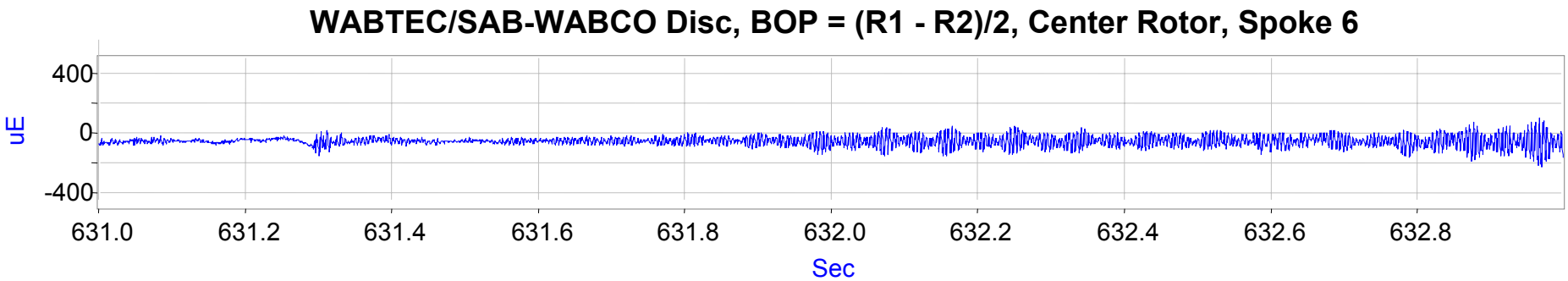
Day 6 – File 25

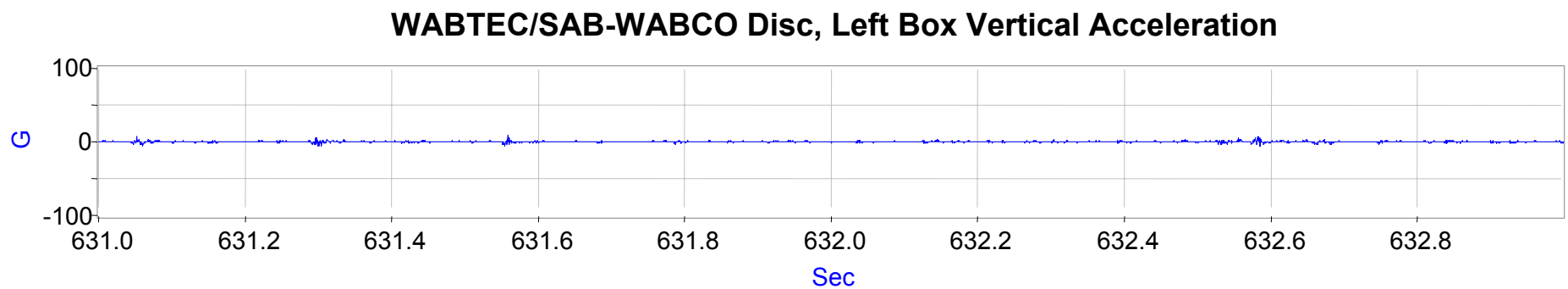

WABTEC/SAB-WABCO Disc, BOP = (R1 - R2)/2, Center Rotor, Spoke 6
uE
400
0
-400
556.0
556.2
556.4
556.6
556.8
557.0
557.2
557.4
557.6
557.8
Sec


WABTEC/SAB-WABCO Disc, Left Box Vertical Acceleration
G
100
0
-100
556.0
556.2
556.4
556.6
556.8
557.0
557.2
557.4
557.6
557.8
Sec


WABTEC/SAB-WABCO Disc, Right Box Vertical Acceleration
G
100
50
0
-50
-100
556.0
556.2
556.4
556.6
556.8
557.0
557.2
557.4
557.6
557.8
Sec

Day 6 – File 25


WABTEC/SAB-WABCO Disc, BOP = (R1 - R2)/2, Center Rotor, Spoke 6
uE
400
0
-400
631.0
631.2
631.4
631.6
631.8
632.0
632.2
632.4
632.6
632.8
Sec


WABTEC/SAB-WABCO Disc, Left Box Vertical Acceleration
G
100
0
-100
631.0
631.2
631.4
631.6
631.8
632.0
632.2
632.4
632.6
632.8
Sec

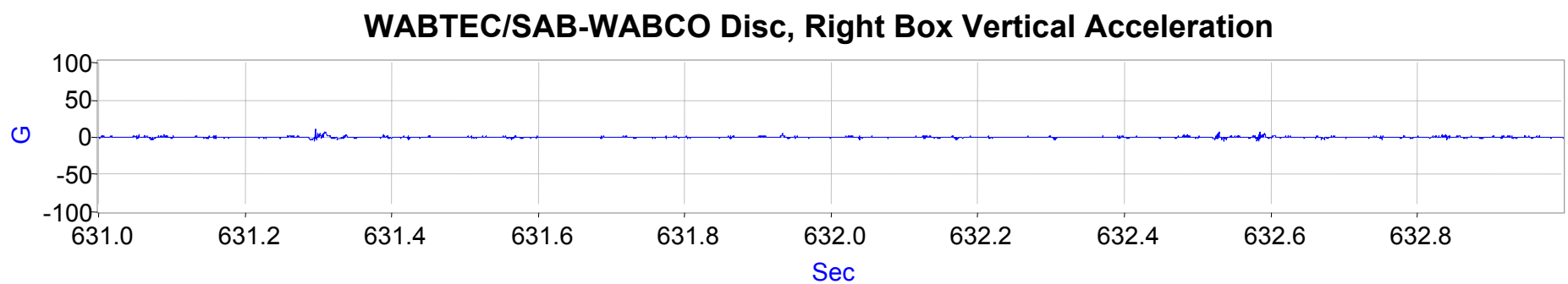

WABTEC/SAB-WABCO Disc, Right Box Vertical Acceleration
G
100
50
0
-50
-100
631.0
631.2
631.4
631.6
631.8
632.0
632.2
632.4
632.6
632.8
Sec

Table F.3 Details of Vertical Accelerations Exceeding 100 G

Num	Day	Location			Physical Track Feature	Axle	Side of Car	Speed (MPH)	Brake Cylinder Pressure (PSI)	Mean Tensile Stress - Center Disc (µE)	Peak BOP - Center Disc (µE)	Acceleration (G)
		Feet	Dir.	MP								
1	5/17	12916	E of	AB225	?	1	Left	119.5	0.6	46	734	103.4
2	5/27	963	NE of	AB224	Plains Interlocking	1	Left	120.1	1.2	61	2258	101.6
3	5/26	2210	NE of	AB223	Forest Interlocking	1	Left	120.3	0.8	589	1015	116.6
4	5/27	1147	SW of	AB224		1	Left	119.2	1.2	58	712	112.4
5	6/18	1952	SW of	AB220	Read Interlocking	2	Right	126.3	0.4	441	305	123.4
6	6/18	2137	SW of	AB220		1	Right	126.2	0.4	413	737	132.3
7	6/18	69	N of	AB219	Switch	2	Right	125.9	0.3	411	286	104.2
8	5/26	721	SW of	AB219		1	Right	108.5	0.8	811	585	145.0
9	6/18	2101	NE of	AB218	Transfer Interlocking	2	Left	131.2	0.3	396	326	178.3
10	6/18	2293	NE of	AB218		1	Left	131.1	0.4	372	1175	106.2
11	5/26	540	SW of	AB170	?	1	Right	143.0	24.1	777	229	103.3
12	6/18	1591	NE of	MN71	Undergrade Bridge	2	Left	43.9	0.3	562	180	102.0
13	6/18	1415	NE of	MN66	CP 266	2	Left	77.4	0.3	289	249	113.7
14	5/17	820	W of	MN61	CP 261	1	Left	54.6	0.9	562	883	106.9
15	6/17	1147	SW of	MN56	Undergrade Bridge	2	Right	47.8	0.4	508	254	112.6
16	6/17	1211	SW of	MN56		2	Left	47.8	0.4	508	254	134.0
17	6/17	1211	SW of	MN56		2	Left	47.8	0.4	508	254	171.6
18	6/17	1276	SW of	MN56		1	Left	47.9	0.4	496	1003	188.9
19	6/17	1276	SW of	MN56		1	Right	47.9	0.4	496	1003	105.7
20	6/17	1276	SW of	MN56		1	Right	47.9	0.4	496	1003	107.3
21	5/26	1315	SW of	MN56		1	Right	43.0	0.6	271	1327	141.2
22	6/18	1448	SW of	MN56		2	Right	41.9	0.4	377	268	119.2

Table F.3 Details of Vertical Accelerations Exceeding 100 G

Num	Day	Location			Physical Track Feature	Axle	Side of Car	Speed (MPH)	Brake Cylinder Pressure (PSI)	Mean Tensile Stress - Center Disc (µE)	Peak BOP - Center Disc (µE)	Acceleration (G)
		Feet	Dir.	MP								
23	5/27	1139	NE of	MN41	CP 241	1	Right	48.0	1.4	334	814	132.3
24	6/18	1510	E of	MN33	CP 234	1	Right	48.9	0.3	270	669	114.8
25	6/17	1872	NE of	MN32	Grade Crossing	2	Left	68.1	14.7	577	284	100.0
26	6/18	2039	NE of	MN32		2	Left	56.2	0.4	244	265	129.3
27	6/17	2164	NE of	MN32		2	Right	64.7	15.1	603	313	106.2
28	5/26	249	NE of	MN29	CP 229	1	Right	69.3	0.8	549	486	111.8
29	5/26	570	SW of	MN29		1	Left	70.1	0.8	565	1405	104.4
30	5/27	348	NE of	MN29		1	Left	71.5	1.3	366	690	132.3
31	6/17	324	SW of	MN29		2	Right	73.2	0.5	687	196	119.2
32	6/17	431	SW of	MN29		1	Left	73.2	0.5	611	554	101.8
33	6/17	431	SW of	MN29		1	Right	73.3	0.5	611	463	120.7
34	6/18	166	NE of	MN29		1	Right	65.3	0.4	373	320	104.5
35	6/18	166	NE of	MN29		2	Right	66.1	0.4	404	354	103.0
36	6/18	428	SW of	MN29		1	Left	70.2	0.4	369	546	132.7
37	6/18	530	SW of	MN29		2	Left	70.7	0.4	402	269	138.4
38	5/27	2154	NE of	MN23	CP 223	1	Right	69.3	1.4	429	1359	108.8
39	6/17	2529	SW of	AN10	Hunter Interlocking	2	Right	73.5	0.5	1250	378	117.0
40	6/17	2634	SW of	AN10		1	Right	73.0	0.5	1203	866	118.2
41	5/17	420	SW of	AN12	Lane Interlocking	1	Left	108.0	0.9	250	720	110.0
42	5/26	1222	SW of	AN12		1	Right	107.3	0.8	610	854	101.9
43	6/18	450	SW of	AN12		1	Left	108.9	0.4	294	601	147.1
44	6/18	450	SW of	AN12		2	Left	108.9	0.4	329	333	127.3

Table F.3 Details of Vertical Accelerations Exceeding 100 G

Num	Day	Location			Physical Track Feature	Axle	Side of Car	Speed (MPH)	Brake Cylinder Pressure (PSI)	Mean Tensile Stress - Center Disc (µE)	Peak BOP - Center Disc (µE)	Acceleration (G)
		Feet	Dir.	MP								
45	5/26	2174	NE of	AN20	Union Interlocking	1	Left	112.6	0.8	213	1279	155.6
46	5/27	1979	SW of	AN19		1	Right	90.1	1.5	325	400	113.5
47	6/17	1371	NE of	AN20		2	Left	111.0	0.5	467	244	104.8
48	6/17	2194	NE of	AN20		2	Left	114.4	0.4	459	595	153.7
49	6/17	2362	NE of	AN20		1	Left	114.1	0.5	477	1379	161.9
50	6/18	1083	NE of	AN20		2	Left	103.0	0.4	1078	283	102.9
51	5/16	1734	E of	AN26	Lincoln Interlocking	1	Left	100.4	1.6	451	416	101.0
52	5/26	1367	E of	AN26		1	Left	97.1	0.8	345	589	124.1
53	5/26	1367	E of	AN26		1	Right	97.1	0.8	344	531	104.6
54	6/17	1316	E of	AN26		1	Left	109.2	0.5	563	1230	136.5
55	6/17	1476	E of	AN26		2	Left	109.2	0.5	584	475	149.3
56	6/17	1796	E of	AN26		1	Right	108.9	0.5	557	812	103.2
57	5/16	872	SW of	AN30	Signal Bridge	1	Left	124.3	1.6	330	149	101.9
58	5/26	45	W of	AN32.5	County Interlocking	1	Left	124.6	0.8	244	599	102.2
59	5/27	300	SW of	AN32.5		1	Right	124.2	1.6	339	756	114.2
60	6/17	35	W of	AN32.5		1	Left	121.2	0.5	446	555	104.6
61	6/17	166	NE of	AN32.5		2	Left	121.1	0.5	441	414	103.5
62	5/17	392	NE of	AN32.5	?	1	Left	119.6	0.9	623	538	117.5
63	5/27	431	NE of	AN32.5		1	Right	123.6	1.6	343	516	111.0
64	5/27	431	NE of	AN32.5		1	Right	123.6	1.6	343	516	120.7
65	6/17	696	NE of	AN32.5		2	Right	119.2	28.3	487	313	110.8
66	5/26	2350	NE of	AN42	Midway Interlocking	1	Left	130.5	0.8	125	524	111.4
67	5/27	1641	SW of	AN41		1	Right	131.7	1.6	208	441	100.6
68	6/17	1939	SW of	AN41		1	Left	134.3	0.5	277	631	103.3
69	6/17	1939	SW of	AN41		2	Left	134.4	0.5	218	272	112.5

Table F.3 Details of Vertical Accelerations Exceeding 100 G

Num	Day	Location			Physical Track Feature	Axle	Side of Car	Speed (MPH)	Brake Cylinder Pressure (PSI)	Mean Tensile Stress - Center Disc (µE)	Peak BOP - Center Disc (µE)	Acceleration (G)
		Feet	Dir.	MP								
70	5/16	984	NE of	AN55.5	Ham Interlocking	1	Left	110.6	0.5	1208	766	126.1
71	5/26	937	NE of	AN55.5		1	Right	108.2	0.8	230	475	129.7
72	5/27	173	N of	AN55.5		1	Left	108.8	1.7	268	1113	124.0
73	6/18	154	W of	AN55.5		1	Right	98.7	55.7	1894	1202	115.8
74	6/18	694	NE of	AN55.5		1	Left	112.3	56.0	1668	1168	117.3
75	6/18	694	NE of	AN55.5		2	Left	111.0	56.0	1779	303	103.0
76	5/16	1726	SW of	AN77	Holmes Interlocking	1	Left	100.6	0.5	304	468	102.2
77	5/17	2512	SW of	AN77		1	Left	98.8	0.9	635	614	109.1
78	5/27	2336	SW of	AN77		1	Right	98.3	1.8	698	823	106.7
79	6/17	1327	SW of	AN77		2	Right	124.1	0.6	317	158	152.3
80	6/17	1509	SW of	AN77		1	Right	124.0	0.6	385	902	150.2
81	6/18	2613	SW of	AN77		1	Left	122.1	0.4	501	978	154.7
82	6/18	2613	SW of	AN77		2	Left	122.0	0.4	422	544	163.4
83	6/18	2143	NE of	AN78		2	Right	121.2	0.4	412	212	110.3
84	6/18	2320	NE of	AN78		1	Right	121.3	0.4	494	879	127.8
85	6/17	486	SW of	AN85.5	N. Phil Interlocking	2	Left	58.1	0.5	653	244	112.5
86	6/17	570	SW of	AN85.5		1	Left	58.0	0.5	719	563	108.4
87	5/16	1676	NE of	AP4	Phil Interlocking	1	Left	94.7	11.8	291	427	103.8
88	6/17	2347	NE of	AP4		2	Left	84.9	44.7	1435	344	102.7
89	6/17	147	NE of	AP16.8	Hook Interlocking	2	Left	109.9	0.4	810	399	120.3
90	5/27	2159	SW of	AP20	Holly Interlocking	1	Right	109.7	2.7	491	413	105.6
91	6/18	1801	SW of	AP20		2	Right	125.7	0.4	295	275	107.6
92	6/17	1352	E of	AP30	Ragan Interlocking	2	Left	124.1	0.5	361	242	105.3
93	6/18	1326	E of	AP30		1	Right	118.1	0.4	728	792	100.4
94	5/26	2362	E of	AP39	Davis Interlocking	1	Right	127.6	1.0	285	620	102.3
95	6/17	2577	W of	AP38		2	Right	133.9	0.5	385	341	121.6

Table F.3 Details of Vertical Accelerations Exceeding 100 G

Num	Day	Location			Physical Track Feature	Axle	Side of Car	Speed (MPH)	Brake Cylinder Pressure (PSI)	Mean Tensile Stress - Center Disc (µE)	Peak BOP - Center Disc (µE)	Acceleration (G)
		Feet	Dir.	MP								
96	5/17	1009	W of	AP60	Grace Interlocking	1	Left	89.1	0.7	751	818	101.5
97	5/27	906	W of	AP60		1	Left	90.4	2.9	855	776	104.5
98	5/27	906	W of	AP60		1	Right	90.4	2.9	855	776	118.2
99	6/18	1180	W of	AP60		2	Left	87.0	0.4	1064	258	110.9
100	6/18	1308	W of	AP60		1	Left	87.0	0.4	1018	1263	117.2
101	5/17	625	NE of	AP63	Oak Interlocking	1	Left	124.2	0.7	564	564	109.8
102	6/17	1038	NE of	AP63		2	Right	124.7	0.5	187	287	109.4
103	5/26	2192	SW of	AP75	Wood Interlocking	1	Right	122.7	2.2	217	580	102.2
104	5/26	2192	SW of	AP75		1	Right	122.7	2.2	217	580	106.7
105	6/17	2256	SW of	AP75		1	Right	124.7	0.4	575	920	113.3
106	6/18	1265	SW of	AP75		1	Left	124.5	0.4	328	1487	145.8
107	6/18	1448	SW of	AP75		2	Left	124.4	0.4	273	290	145.3
108	5/17	621	NW of	AP94	Biddle Interlocking	1	Left	48.9	0.7	644	479	105.3
109	6/18	709	NW of	AP94		1	Left	46.1	4.7	861	863	107.8
110	6/17	2294	S of	AP102	?	1	Left	124.0	0.5	230	651	118.5
111	6/17	2477	S of	AP102		2	Left	123.9	0.5	231	307	104.2
112	6/17	2476	S of	AP112	Grove Interlocking	1	Left	124.7	0.5	240	1028	102.7

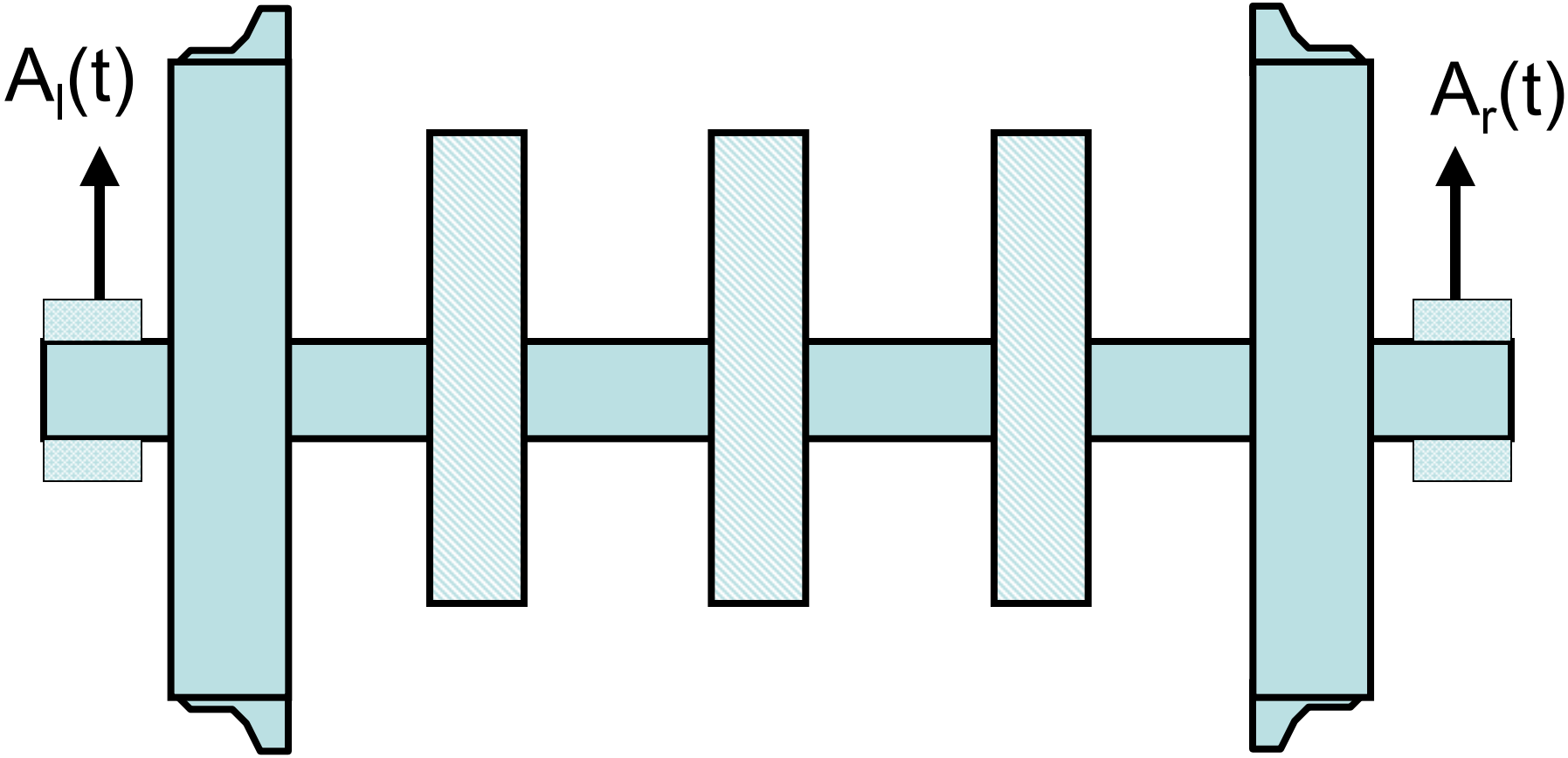
Vertical Acceleration Events

- For any given sensor location, vertical acceleration exceeds 100G on the axle boxes approximately 5 – 13 times per day
- The events where acceleration exceeds 100 G can be grouped into approximately 48 instances for the entire Northeast Corridor for all 6 runs between Boston and DC
- The correlation between accelerations above 100 G and speed is small
- Accelerations above 100 G were observed at speeds greater than 40 mph
- The number of high acceleration events remains similar each day and on each axle
- The Silicon Design accelerometers used on the right box on Days 1 and 2 produced questionable results
- Vertical acceleration events sometimes cause a brake disc oscillation of short duration regardless of whether brakes are applied
- Vertical acceleration events are usually not associated with sustained brake disc oscillations that occur during braking
- Vertical acceleration events during sustained oscillation can increase the severity of the BOP for a short duration

Relationship of BOP Strain During Non-Braking Conditions to Acceleration Differences

The Problem

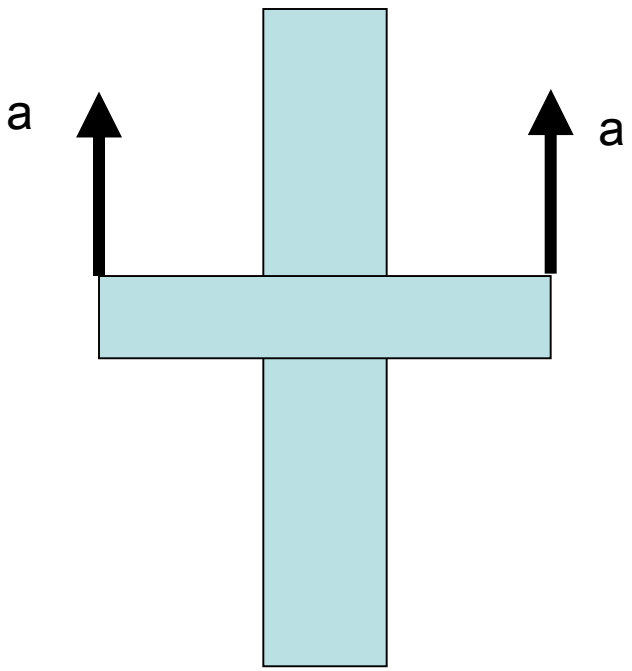
- During Non-braking Conditions, The WABTEC/SAB-WABCO Disc Responds To Track Input From Both The Right Rail Or The Left Rail
- The Response Mode Is An Asymmetric Out Of Plane Bending Of The Spokes
- What Are The Characteristics Of This Response?



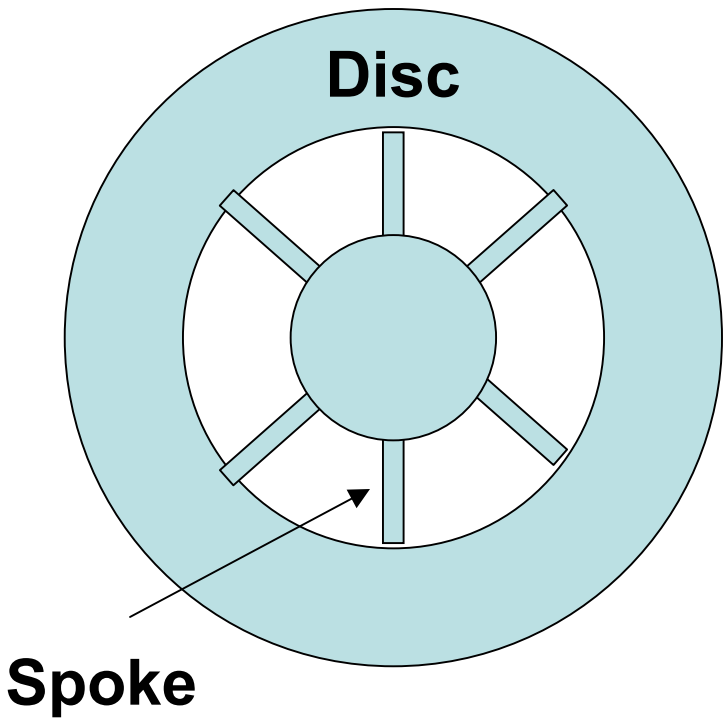
Acceleration Difference=$A_l(t) - A_r(t)$

Model Bump Acceleration

Motion



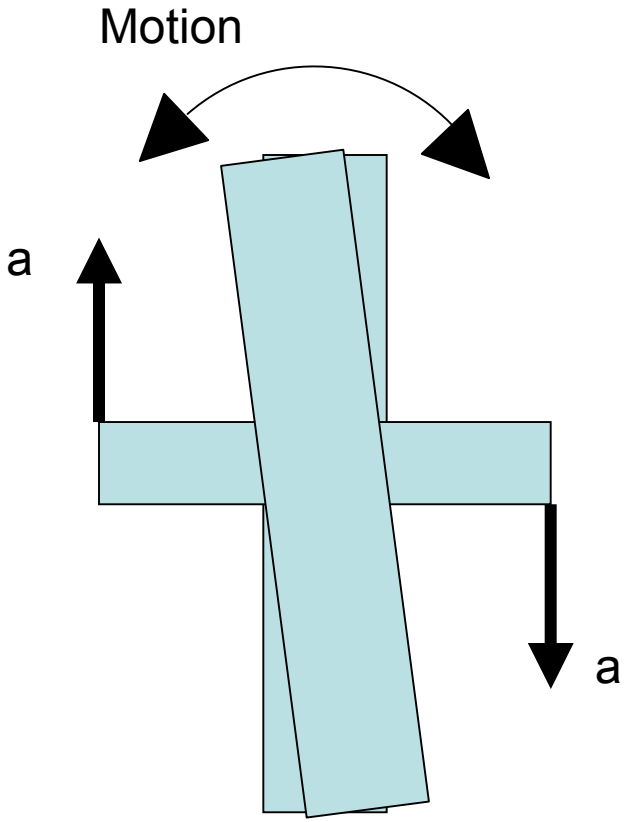
Equal Accelerations
In Same Direction



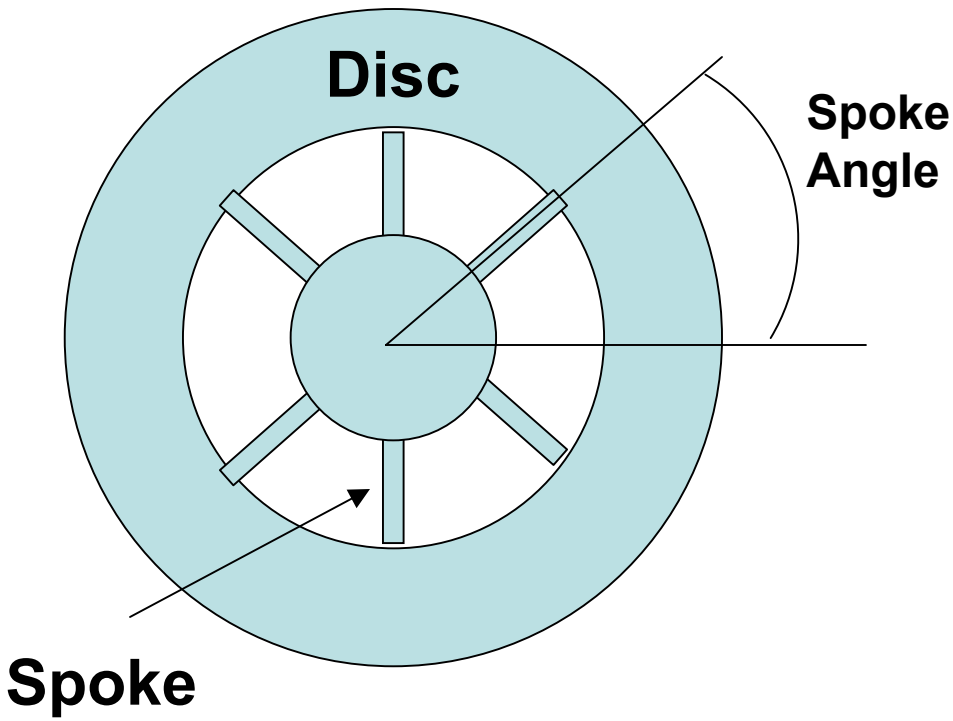
Model for Bump Acceleration

- This Mode Of Motion Does Not Excite An Out Of Plane Response Of The Spokes
- Since The Major Events Of High Axle Box Acceleration Are Predominantly A Single Side Event, The Value Of The Bump Acceleration Is Approximately Equal To The Acceleration Difference

Model for Acceleration Difference



Equal and Opposite Accelerations

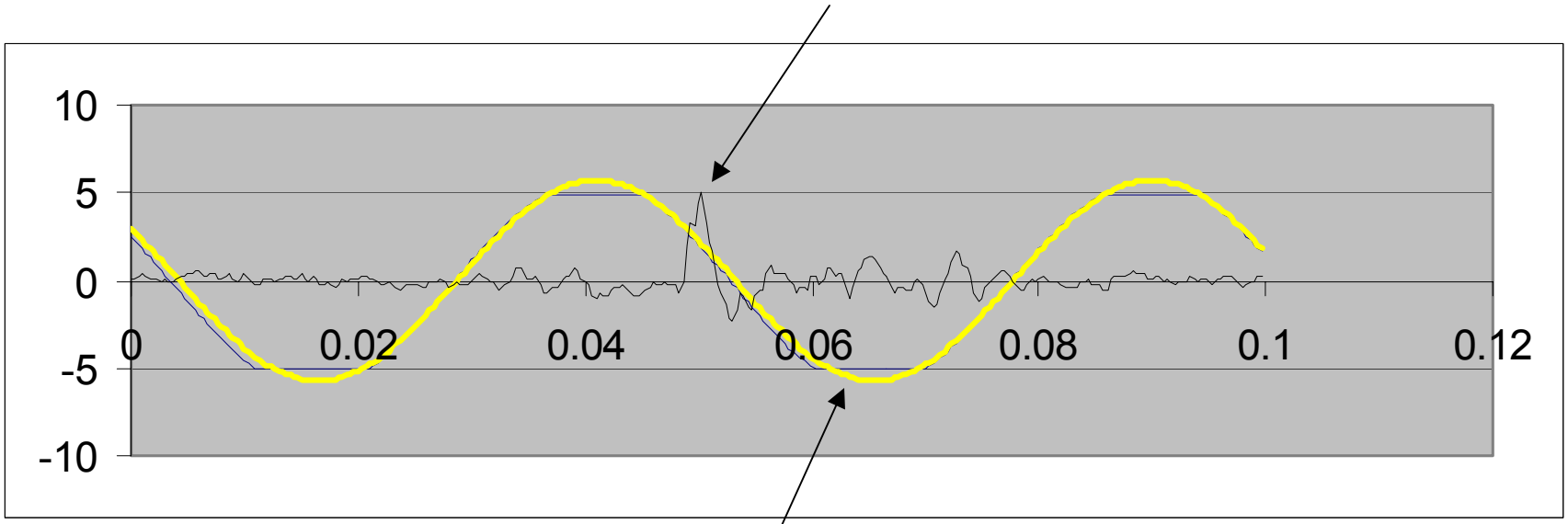


Approach

- Selected Events From May 26 Where Right Acceleration Levels Were Above 100 G's
- Observed BOP Strains Resulting From These Events
- Analyzed The Tilt Acceleration And Spoke 6 BOP Levels
- Plotted Tilt Acceleration Times The Sine Of Spoke 6 Position Angle Versus The Peak BOP Acceleration That Resulted From This Acceleration

Example 1

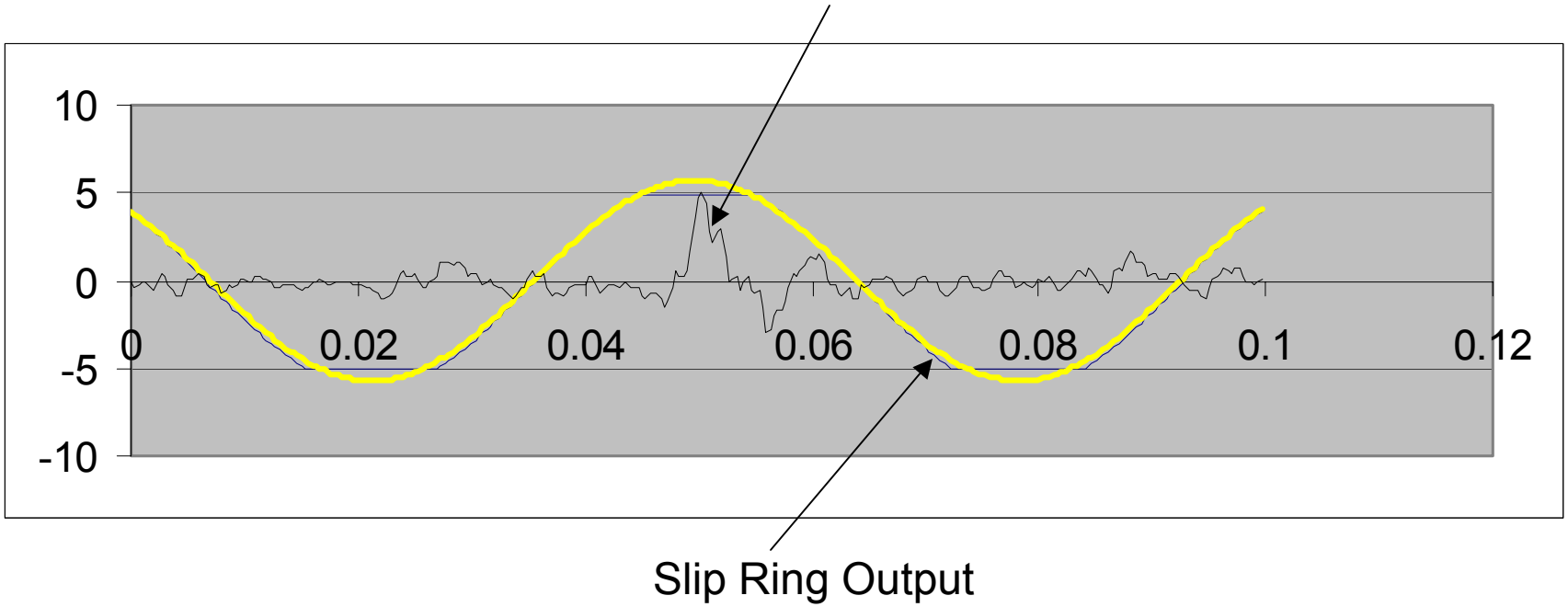
Tilt Acceleration normalized to a peak value of 5 to allow the peak acceleration signal to be associated with a phase angle (for analysis purposes only)



Slip Ring Output

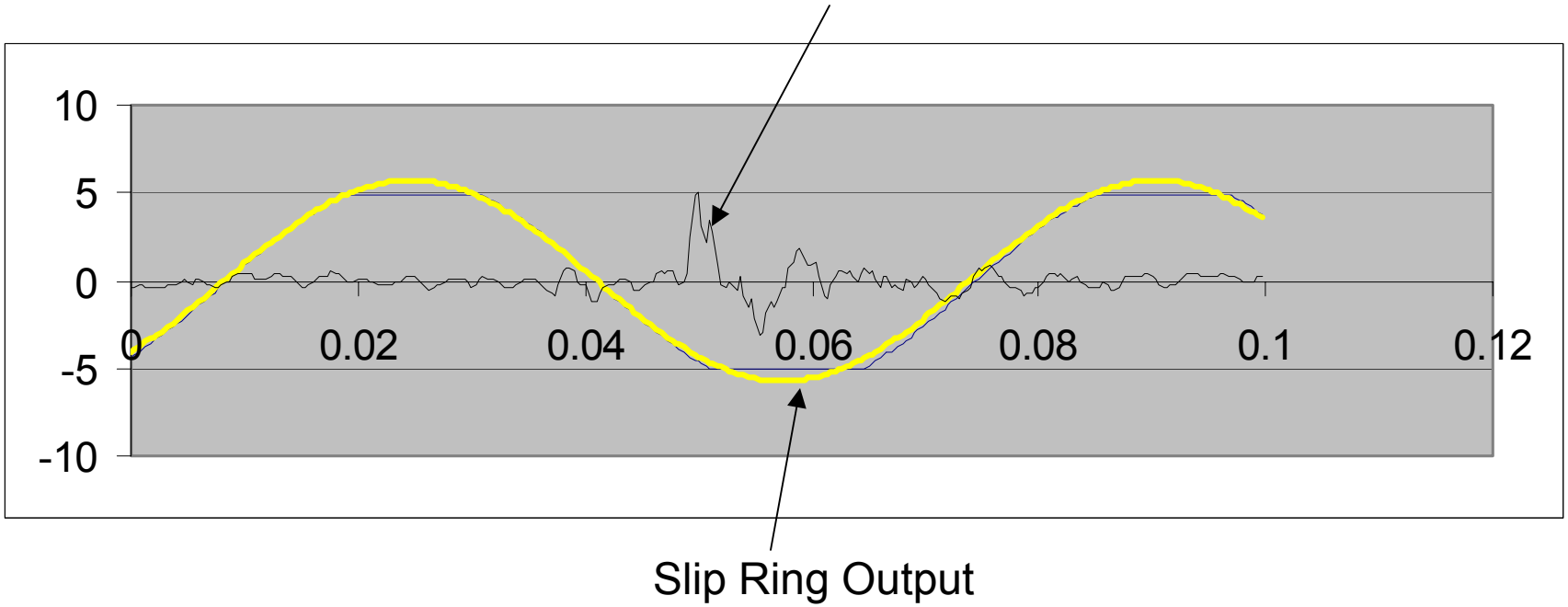
Example 2

Tilt Acceleration normalized to a peak value of 5 to allow the peak acceleration signal to be associated with a phase angle (for analysis purposes only)



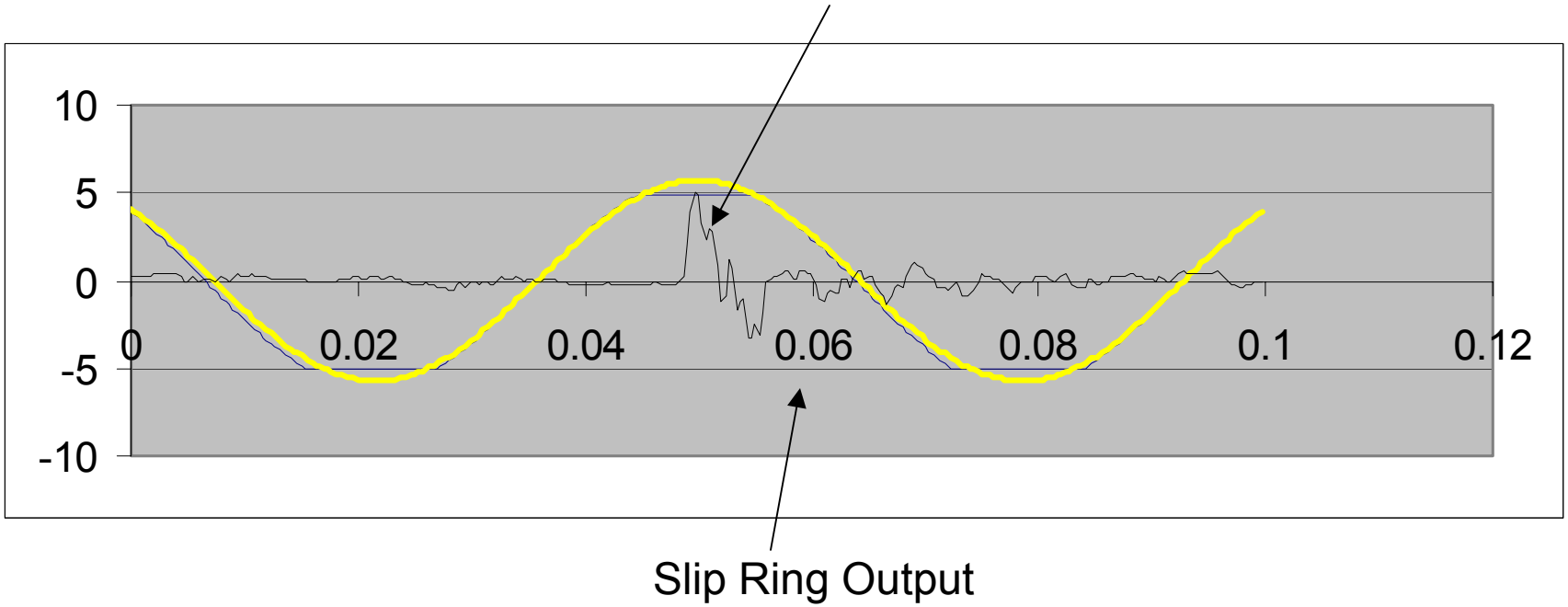
Example 3

Tilt Acceleration normalized to a peak value of 5 to allow the peak acceleration signal to be associated with a phase angle (for analysis purposes only)



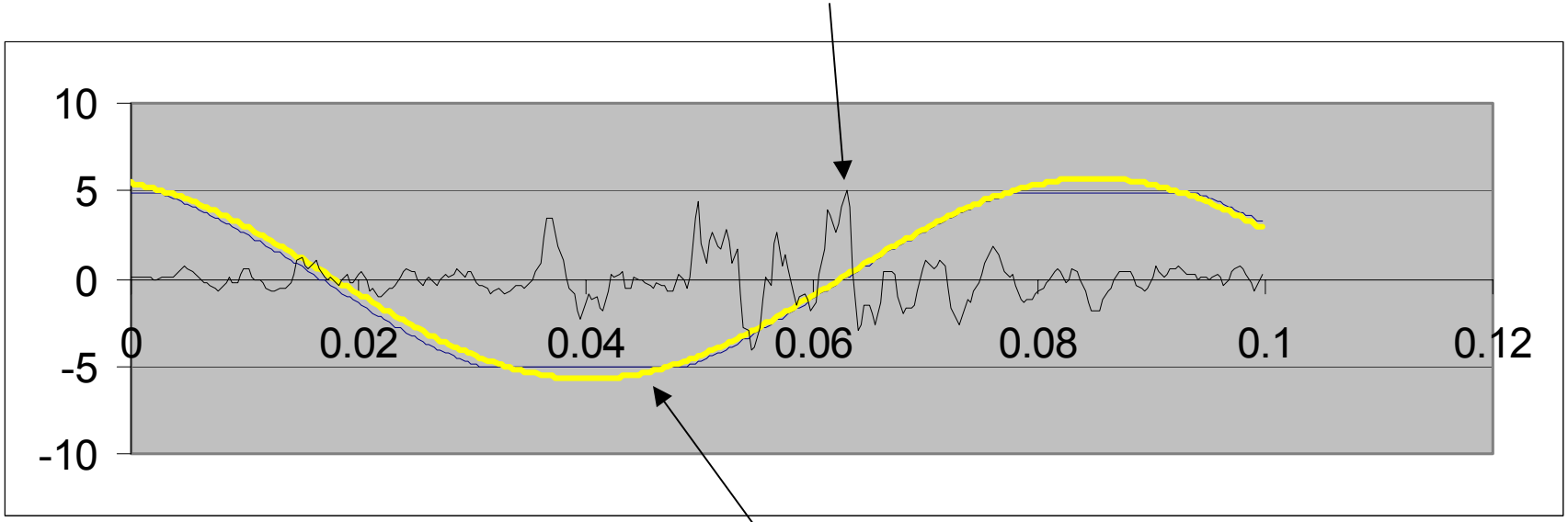
Example 4

Tilt Acceleration normalized to a peak value of 5 to allow the peak acceleration signal to be associated with a phase angle (for analysis purposes only)



Example 5

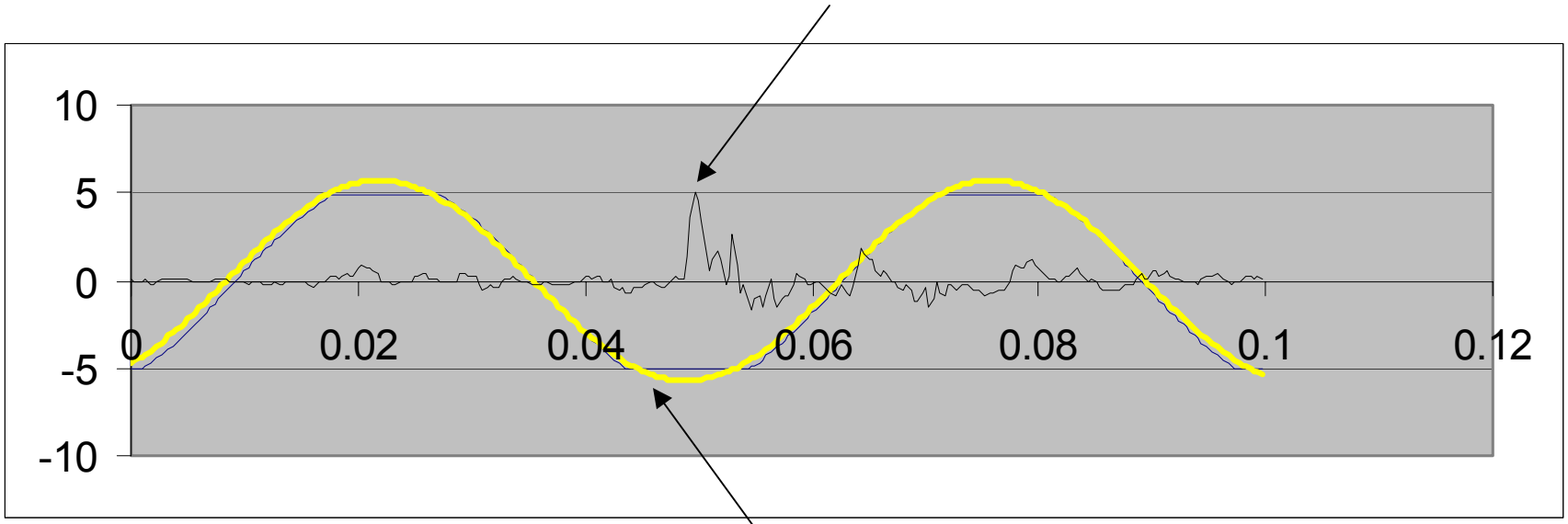
Tilt Acceleration normalized to a peak value of 5 to allow the peak acceleration signal to be associated with a phase angle (for analysis purposes only)



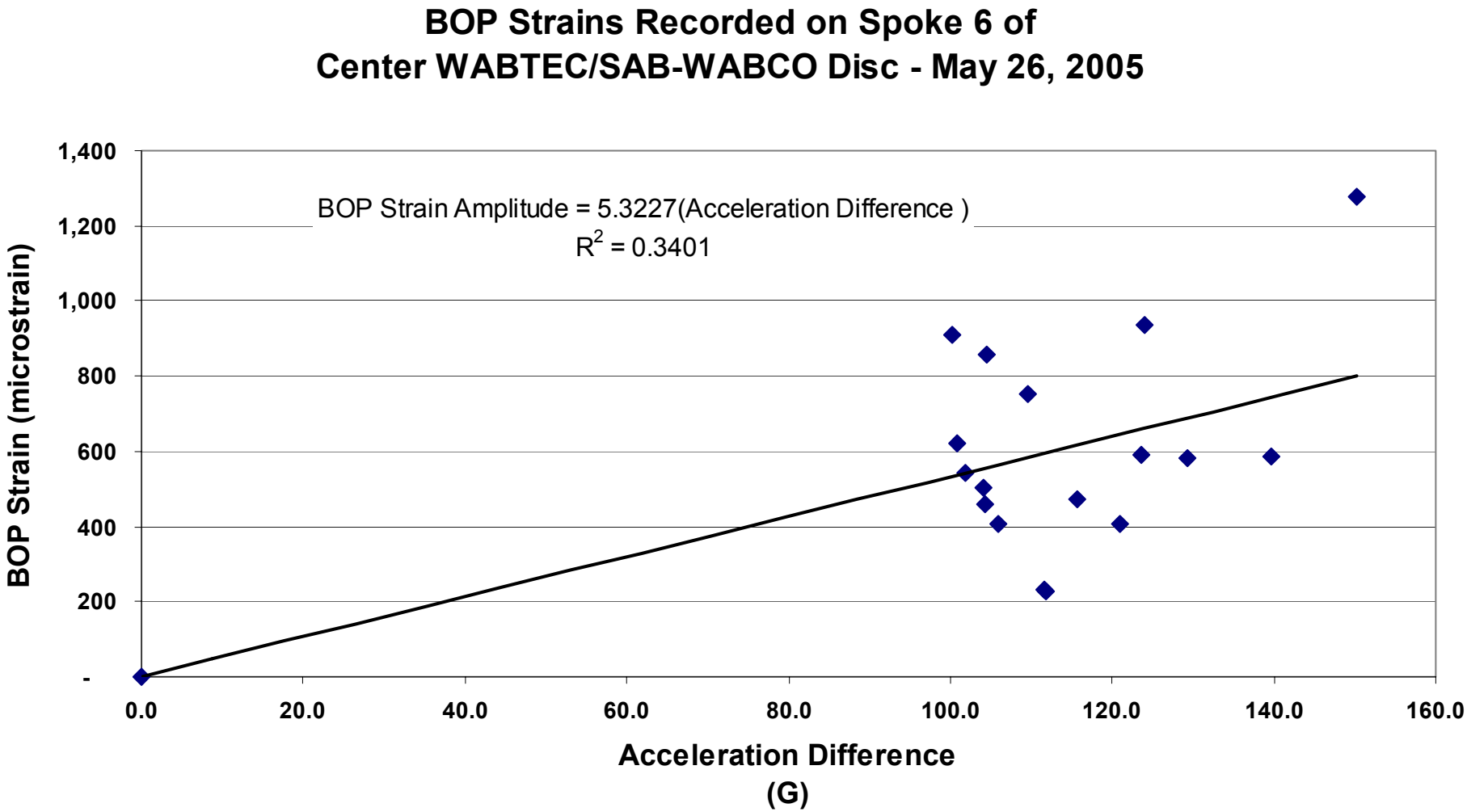
Slip Ring Output

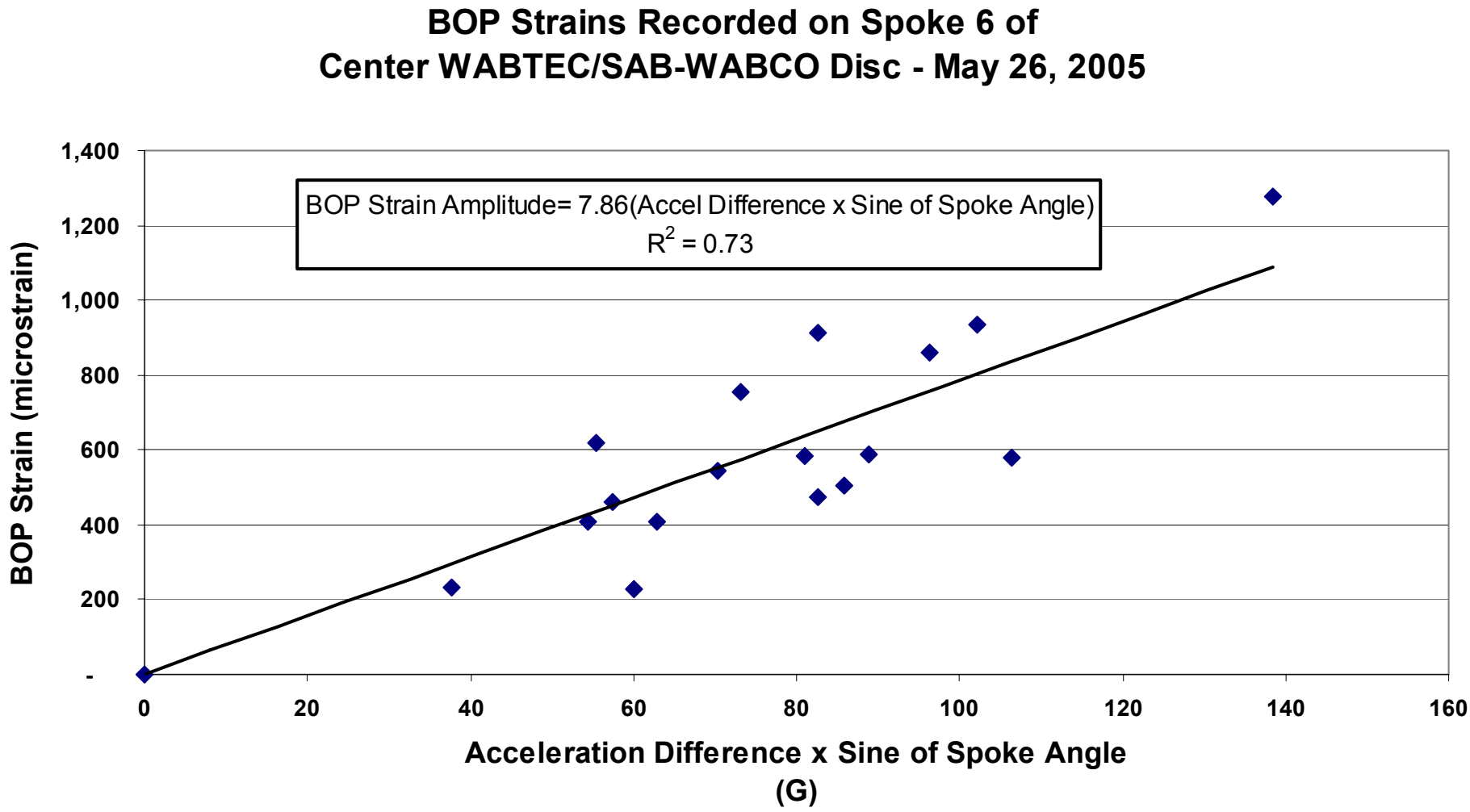
Example 6

Tilt Acceleration normalized to a peak value of 5 to allow the peak acceleration signal to be associated with a phase angle (for analysis purposes only)



Slip Ring Output


BOP Strains Recorded on Spoke 6 of
Center WABTEC/SAB-WABCO Disc - May 26, 2005
BOP Strain Amplitude = 5.3227(Acceleration Difference)
R2 = 0.3401
BOP Strain (microstrain)
1,400
1,200
1,000
800
600
400
200
-
0.0
20.0
40.0
60.0
80.0
100.0
120.0
140.0
160.0
Acceleration Difference
(G)


BOP Strains Recorded on Spoke 6 of
Center WABTEC/SAB-WABCO Disc - May 26, 2005
BOP Strain Amplitude= 7.86(Accel Difference x Sine of Spoke Angle)
R^2 = 0.73
BOP Strain (microstrain)
1,400
1,200
1,000
800
600
400
200
-
0
20
40
60
80
100
120
140
160
Acceleration Difference x Sine of Spoke Angle
(G)

Conclusions

- The BOP Response To Single Track Related Acceleration Pulses Are Proportional To The Level of Acceleration Differences And The Sine Of The Spoke Angular Position
- Based On The Limited Sample

BOP=7.5 Tilt Sin (Spoke Angle)

Comparison of Response of WABTEC/SAB-WABCO and Knorr Brake Discs

Table F.4. Statistics, Axle 1, 6/17/2005

Min	Max	Mean	Stdev	RMS	Channel
-213.8	170.8	-0.1	1.2	1.5	CH01_AXLELAT1-1
-15.8	11.6	0.0	0.7	0.5	CH02_02_TRFLLAT1
-18.4	24.0	0.0	0.7	0.6	CH03_TRFLVERT1
-11.8	18.8	0.0	0.6	0.3	CH04_TRFLLONG1
-9.1	8.5	0.0	0.5	0.2	CH05_BRMTLAT1
-9.0	10.4	0.0	0.6	0.3	CH06_BRMTVERT1
-12.9	15.6	0.0	0.5	0.3	CH09_BRMTLONG1
-53.4	48.6	0.0	1.1	1.3	CH10_CTRCALPLAT1
-31.1	31.3	0.2	0.9	0.8	CH11_CTRCALPVERT1
-17.1	16.6	0.1	0.5	0.3	CH12_CTRCALPLONG1
-42.6	58.5	0.0	0.8	0.6	CH54_LBOXLAT1
-73.5	188.9	0.0	1.2	1.5	CH55_LBOXVERT1
-51.4	39.3	0.0	0.8	0.6	CH56_RBOXLAT1
-58.7	150.2	0.0	1.3	1.6	CH57_RBOXVERT1

Table F.5. Statistics, Axle 1, 6/17/2005

Min	Max	Mean	Stdev	RMS	Channel
-31.9	39.0	-0.1	0.8	0.6	CH16_AXLELAT2
-15.9	17.3	0.0	0.8	0.6	CH17_TRFLLAT2
-17.3	23.8	0.0	0.8	0.6	CH18_TRFLVERT2
-13.7	25.4	0.0	0.6	0.4	CH19_TRFLLONG2
-8.4	7.6	0.0	0.5	0.2	CH20_BRMTLAT2
-10.6	12.2	0.0	0.5	0.3	CH21_BRMTVERT2
-12.9	10.5	0.0	0.5	0.3	CH22_BRMTLONG2
-44.8	39.7	-0.1	0.6	0.3	CH23_CTRCALPLAT2
-31.5	26.2	0.0	0.7	0.5	CH24_CTRCALPVERT2
-14.9	12.8	0.2	0.5	0.3	CH25_CTRCALPLONG2
-124.4	122.3	0.0	1.4	2.1	CH58_LBOXLAT2
-64.4	171.6	0.0	1.3	1.6	CH59_LBOXVERT2
-86.9	155.4	0.0	1.3	1.7	CH60_RBOXLAT2
-69.2	152.3	0.0	1.2	1.5	CH61_RBOXVERT2

Locations for the Following Plots

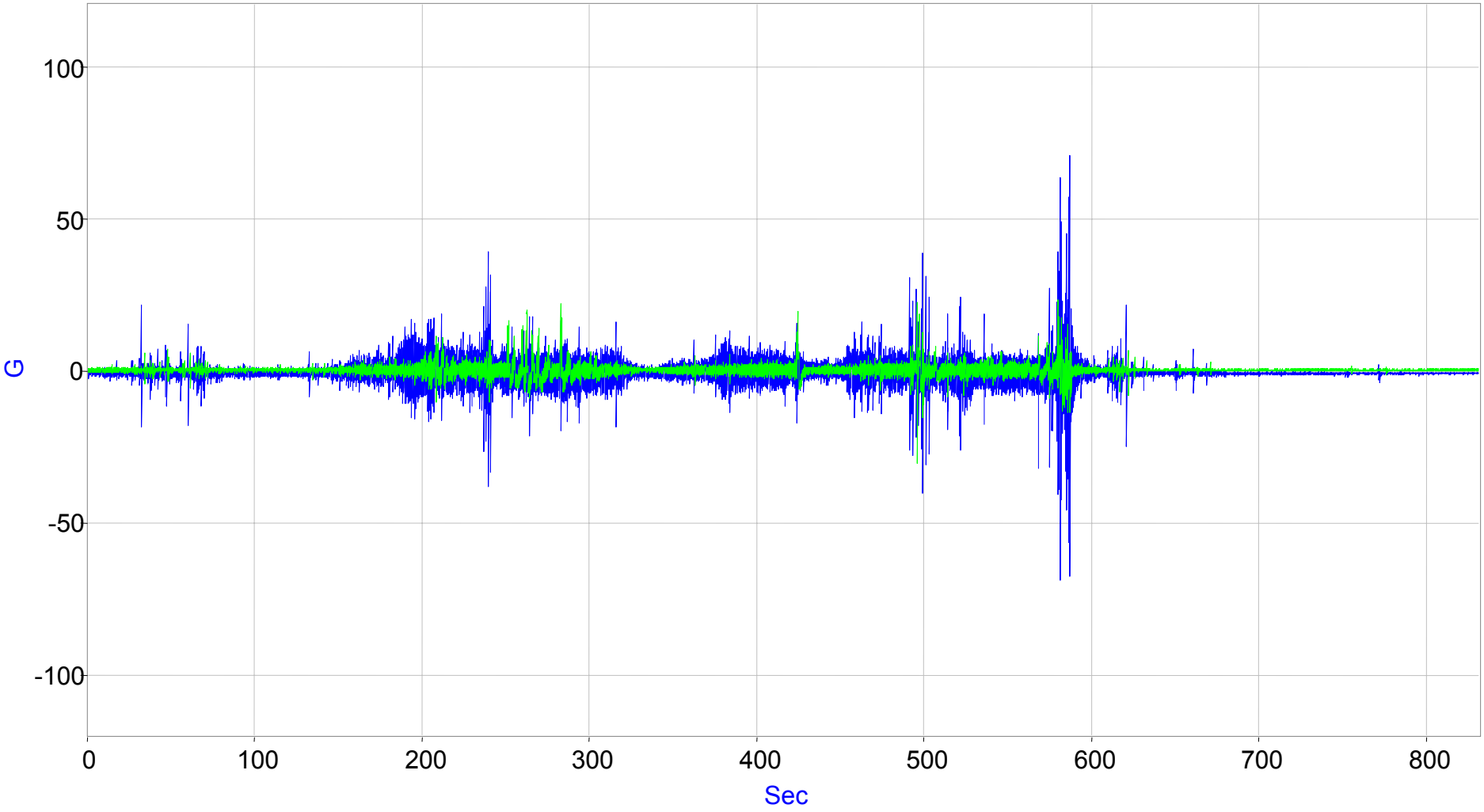
Day	File	Time of File (sec)	Speed (MPH)	Brake Pressure (PSI)	BOP
6/18	24	310	110	56	No
6/18	24	581	106	56	Yes
6/18	30	732	125	0	Yes

Axle Accelerations Examples

- June 18, 2005 File 24, t = 310 - No BOP, Braking
- June 18, 2005 File 24, t = 581 - BOP, Braking
- June 18, 2005 File 30, t=732 – BOP, Response to Impact

6/18/2005 – File 24

Axle Lateral Accel, blue = WABTEC/SAB-WABCO, green = Knorr



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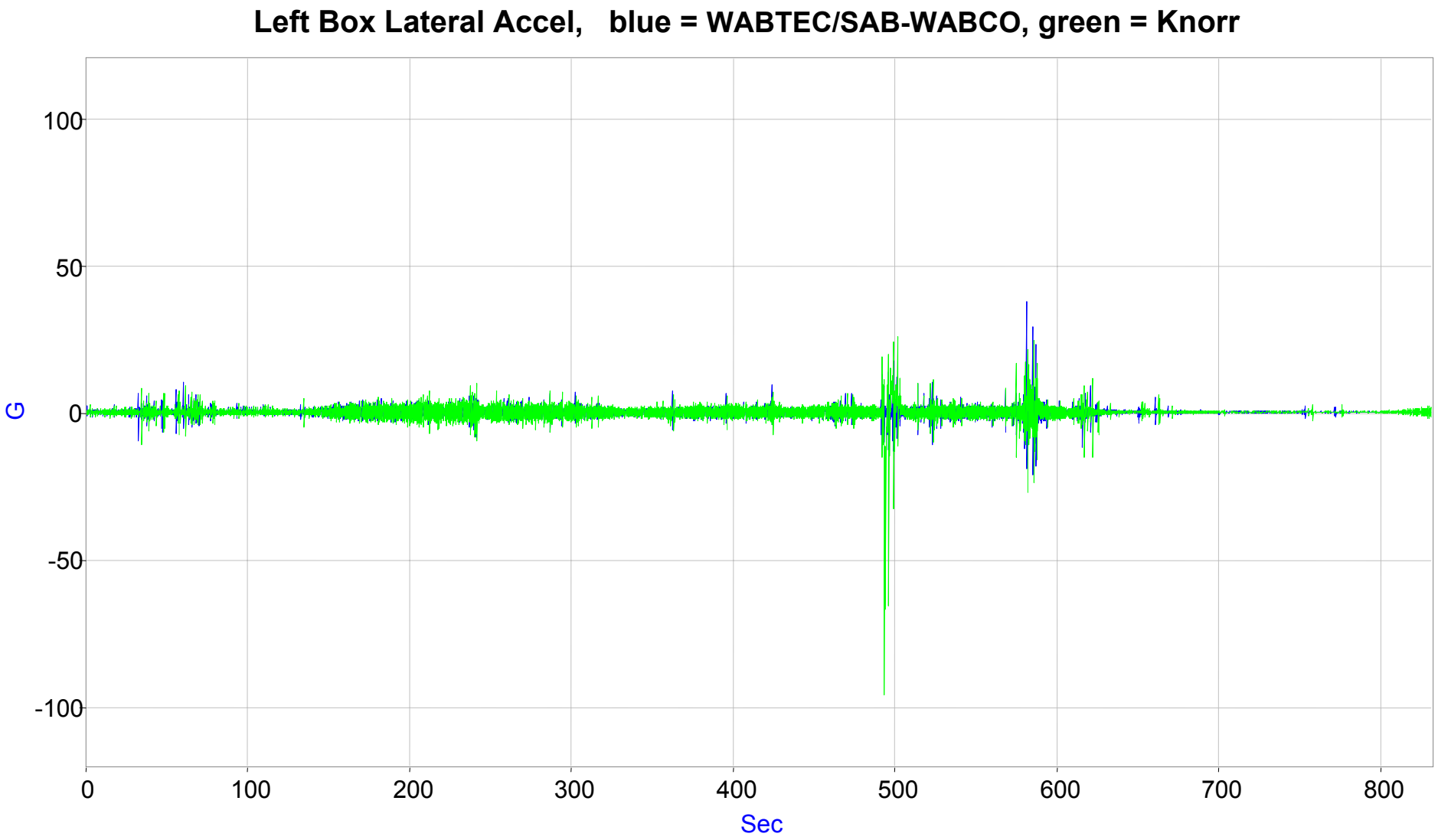

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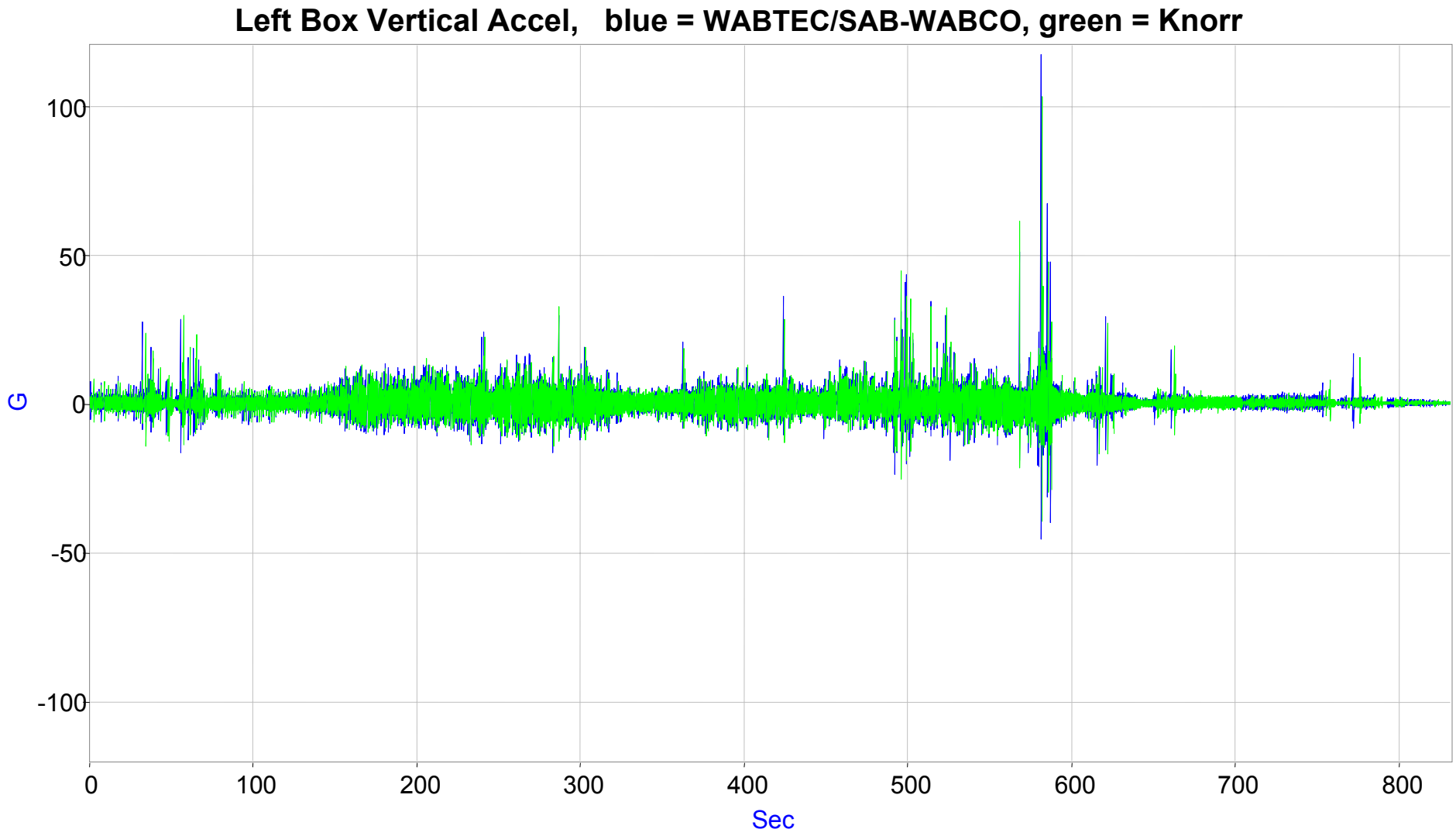
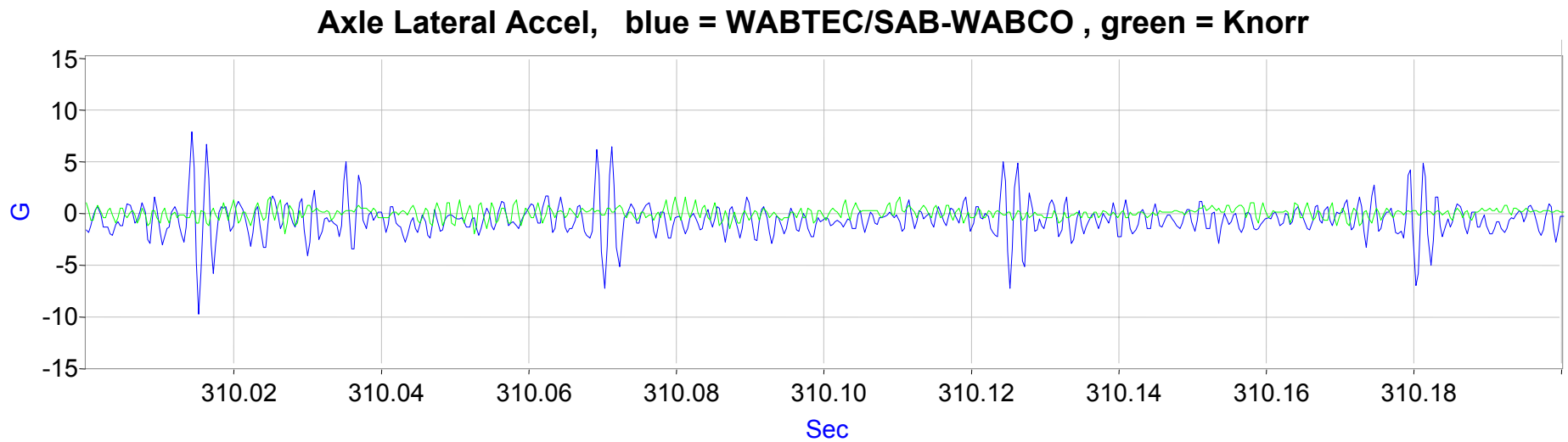
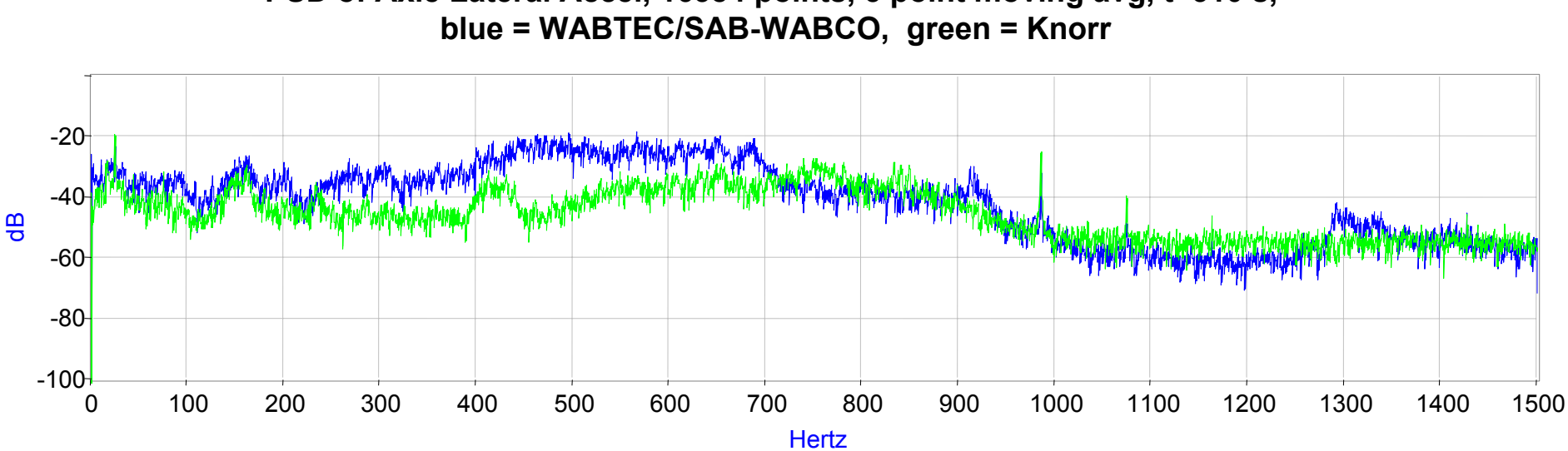


6/18/2005 – File 24 (brake, no SO)





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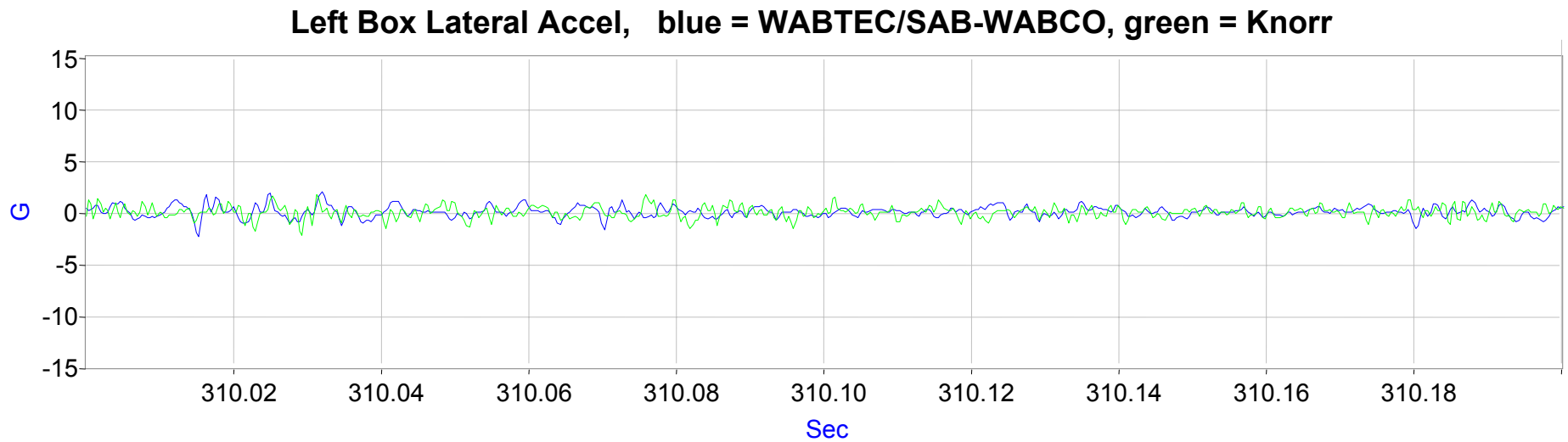
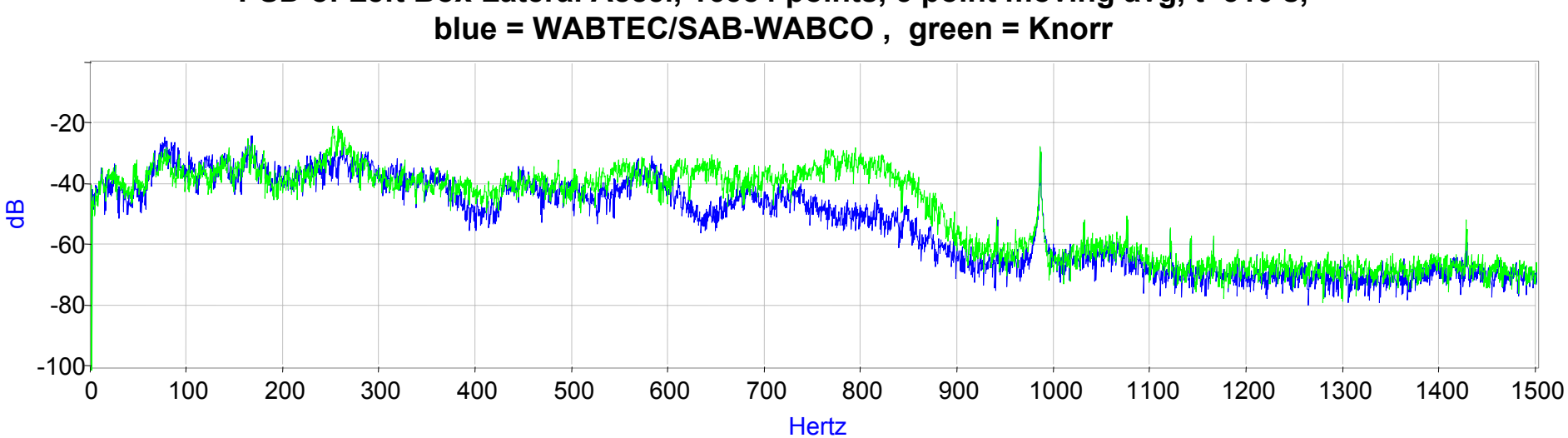
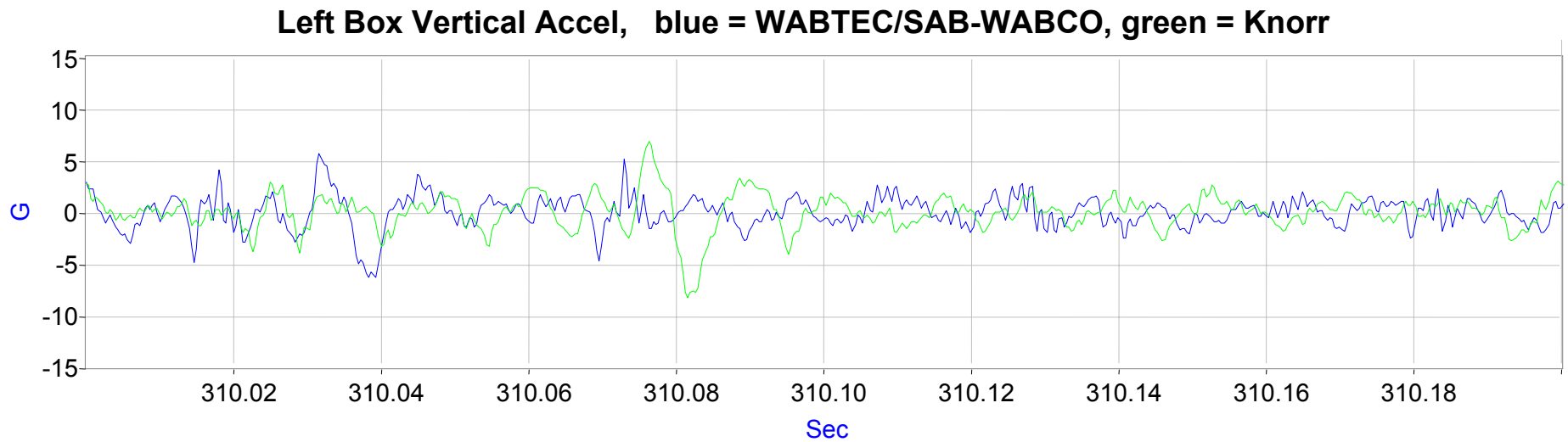
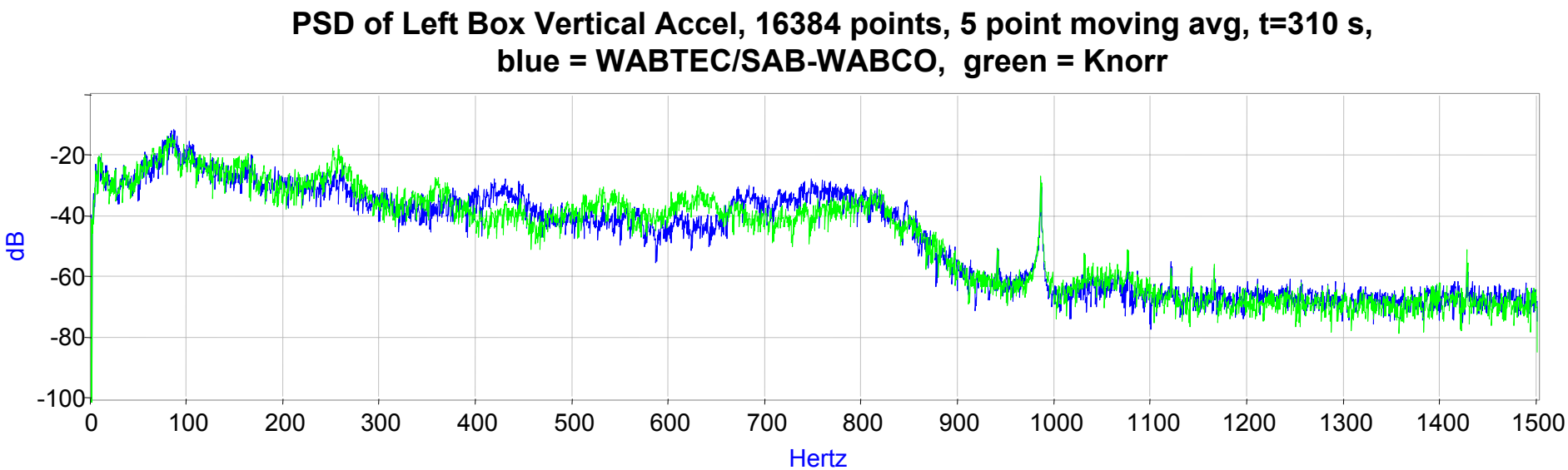


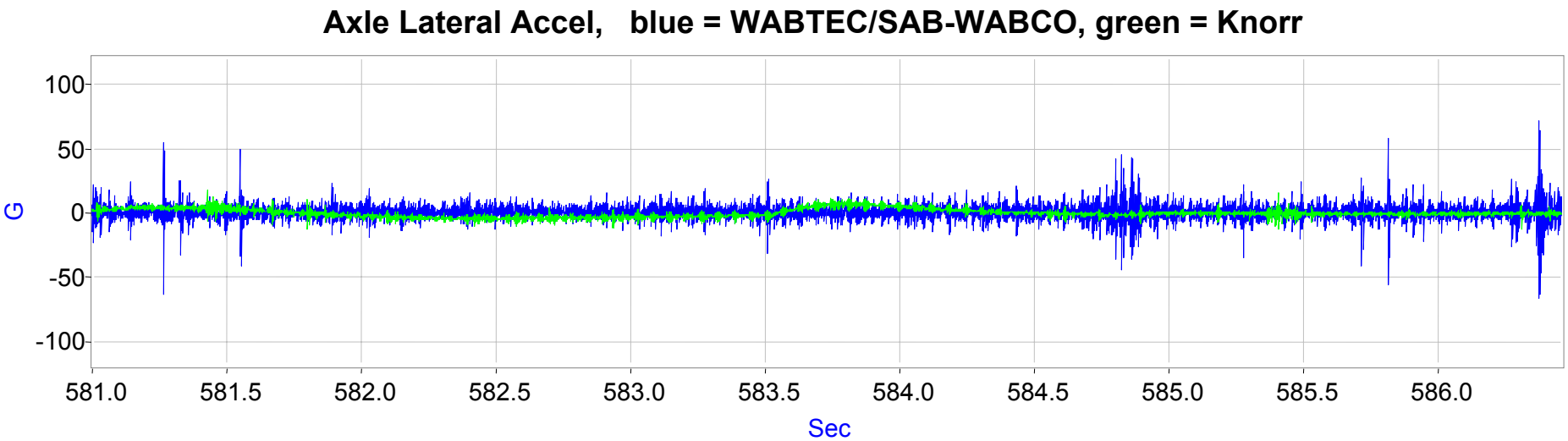


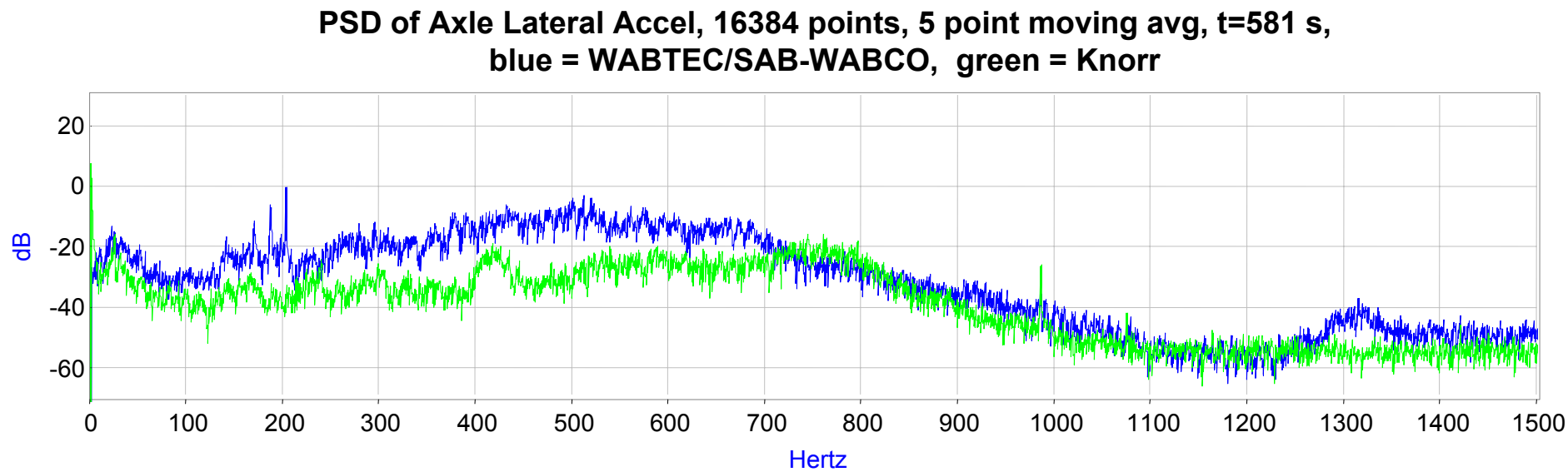
6/18/2005 – File 24 (brake, no SO)



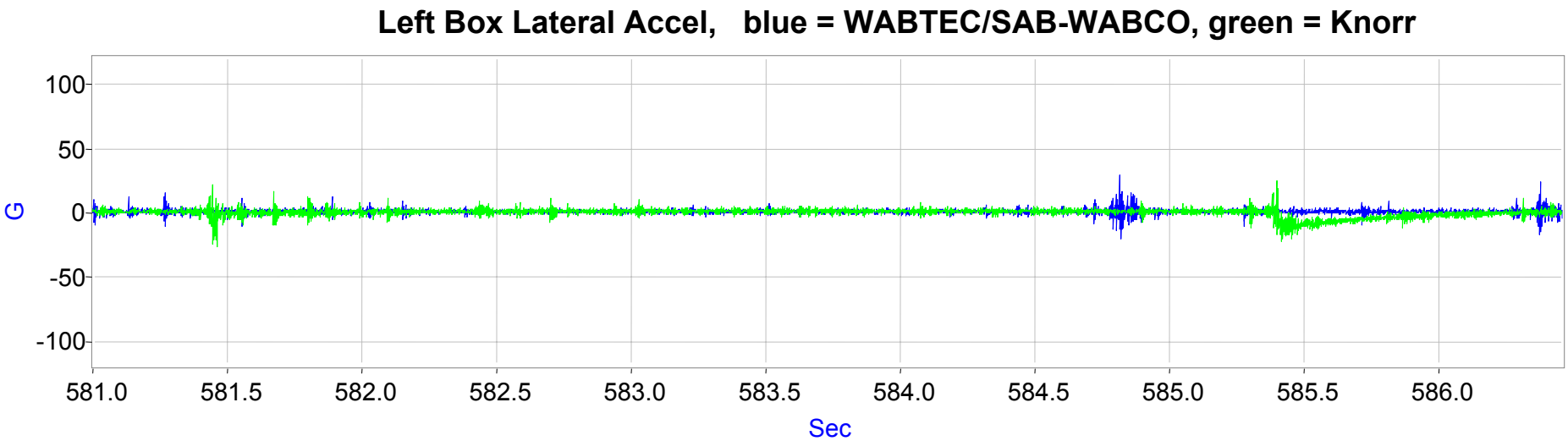


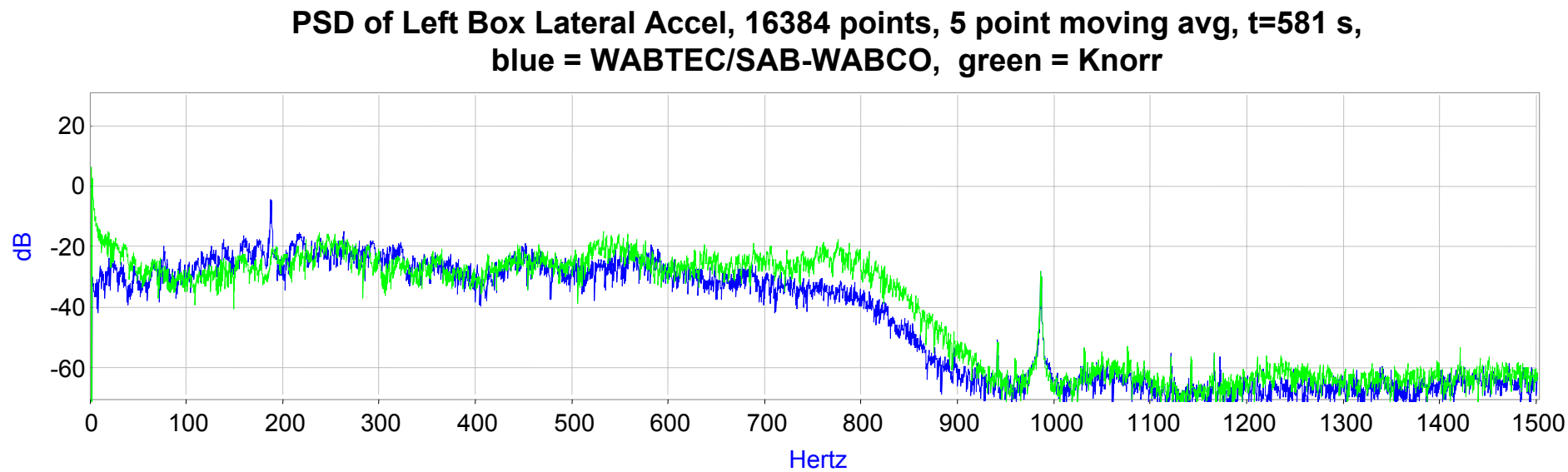
6/18/2005 – File 24 (brake, SO)



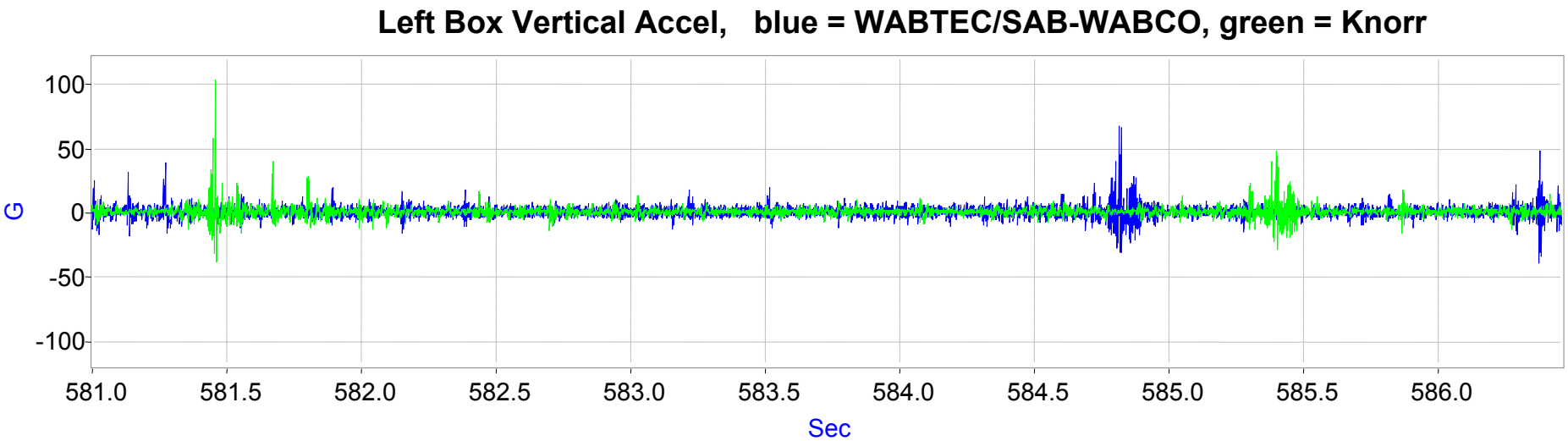


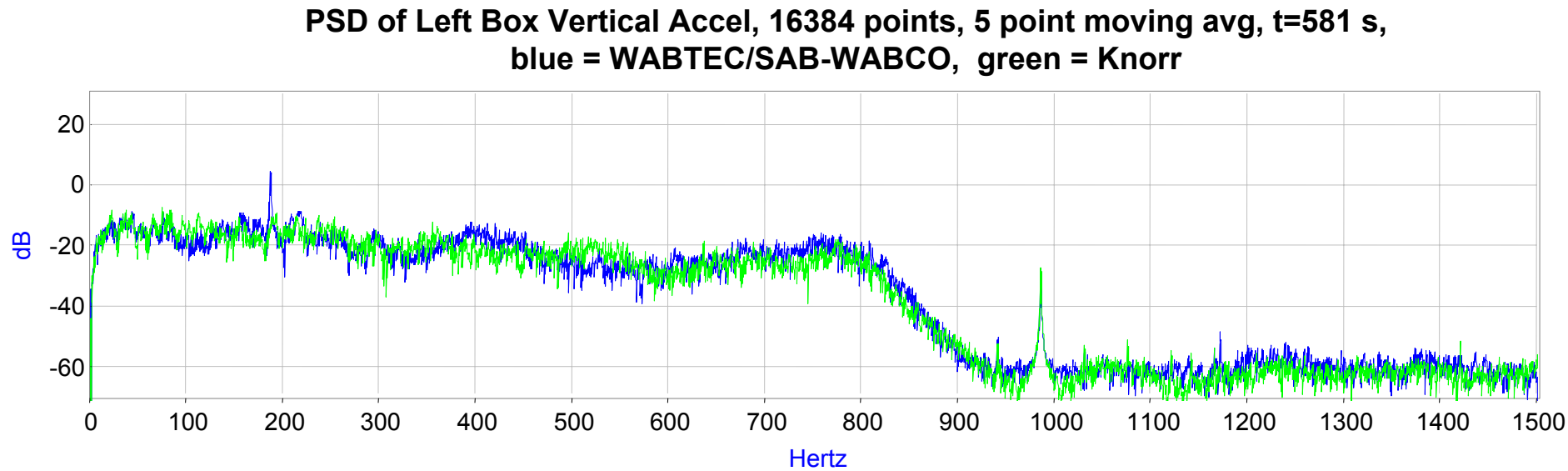
6/18/2005 – File 24 (brake, SO)



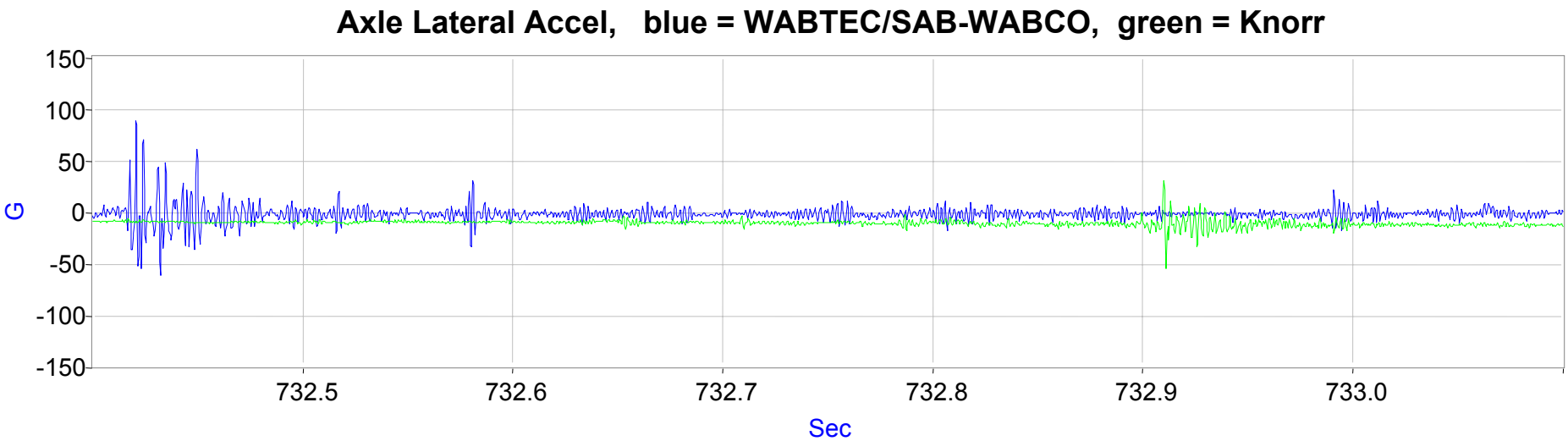


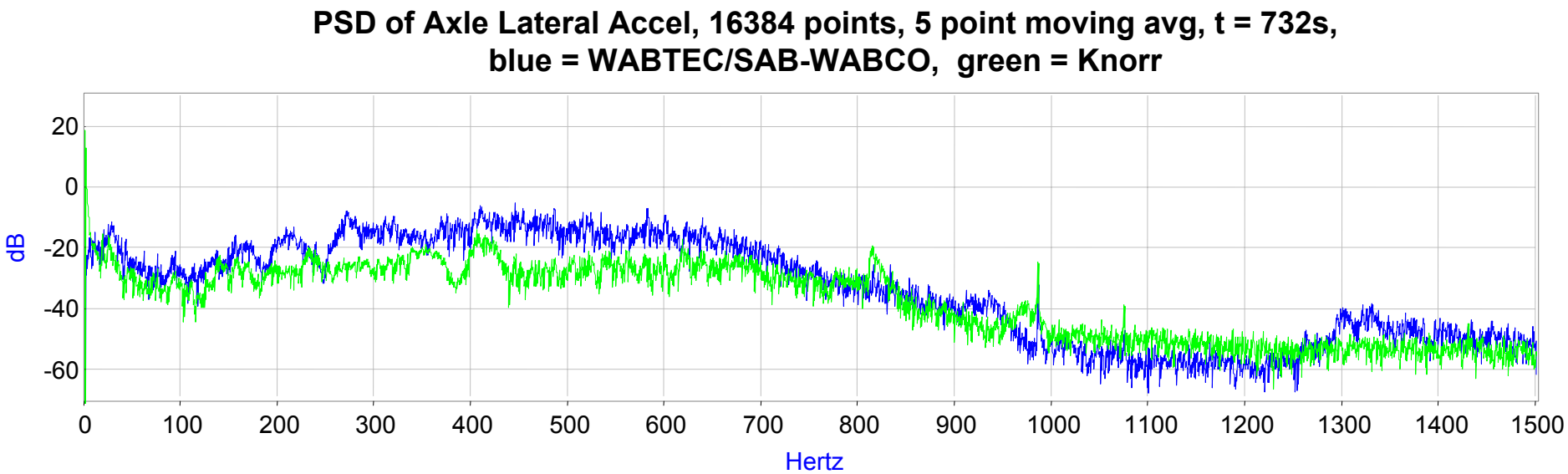
6/18/2005 – File 24 (brake, SO)



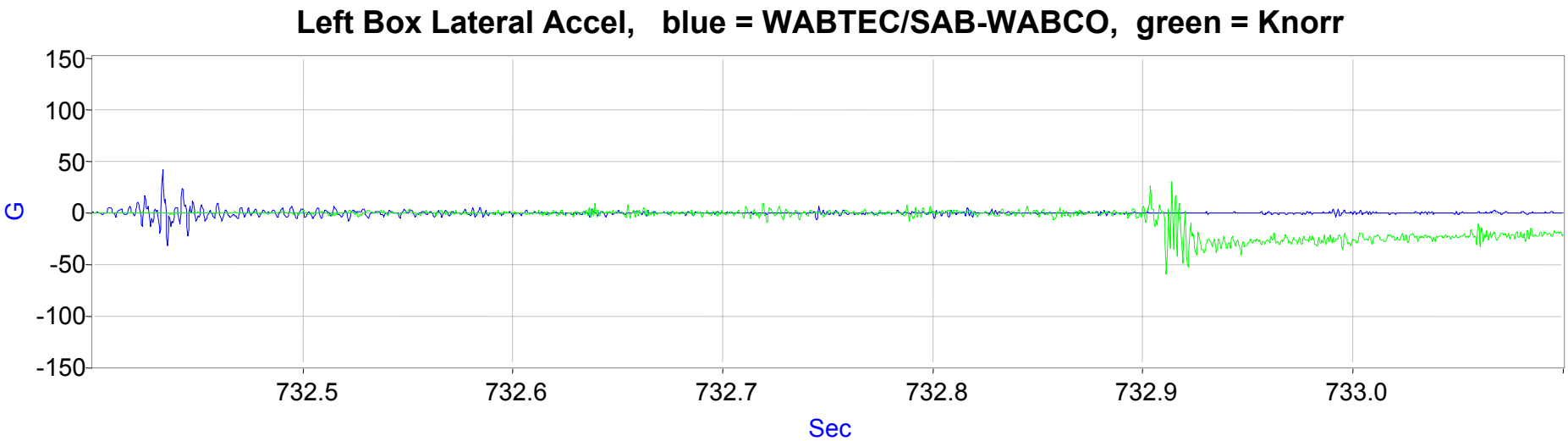


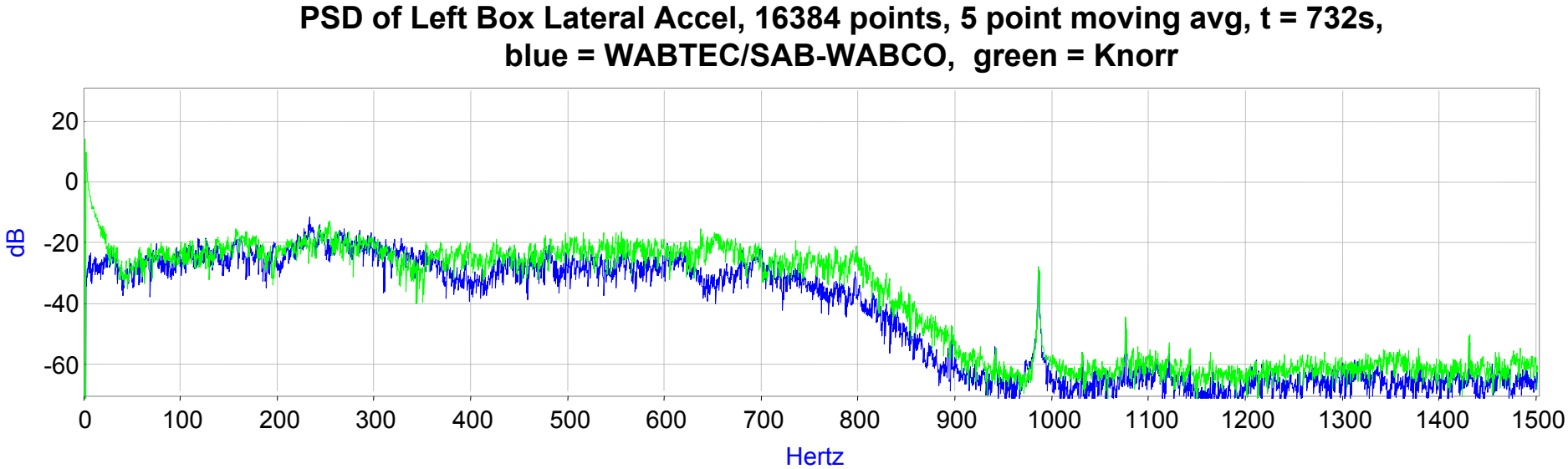
6/18/2005 – File 30 (no brake)



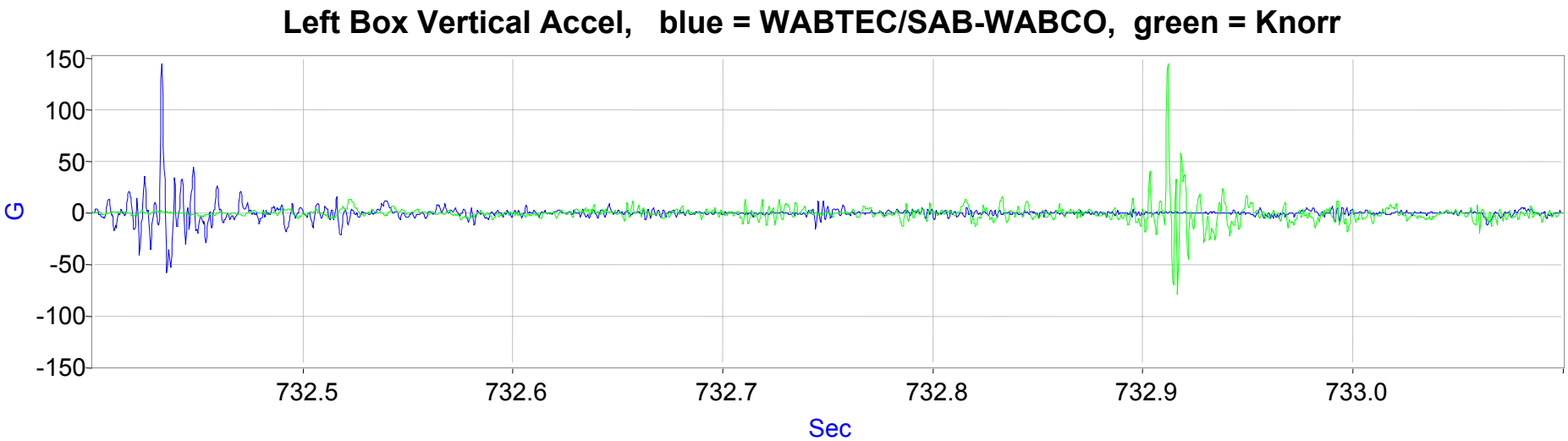


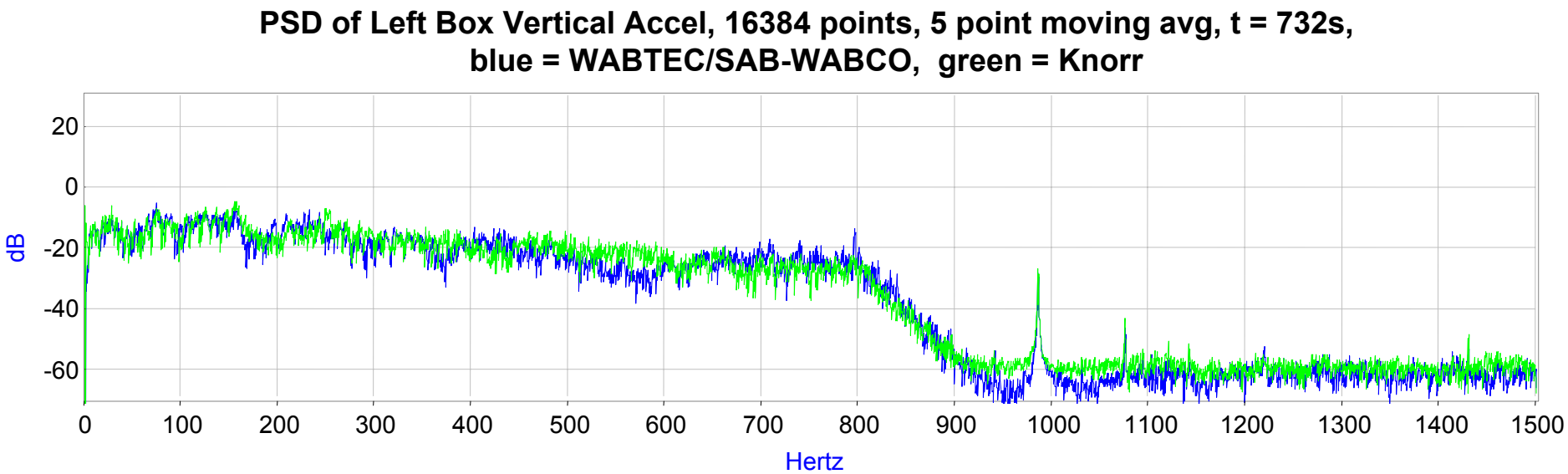
6/18/2005 – File 30 (no brake)





6/18/2005 – File 30 (no brake)



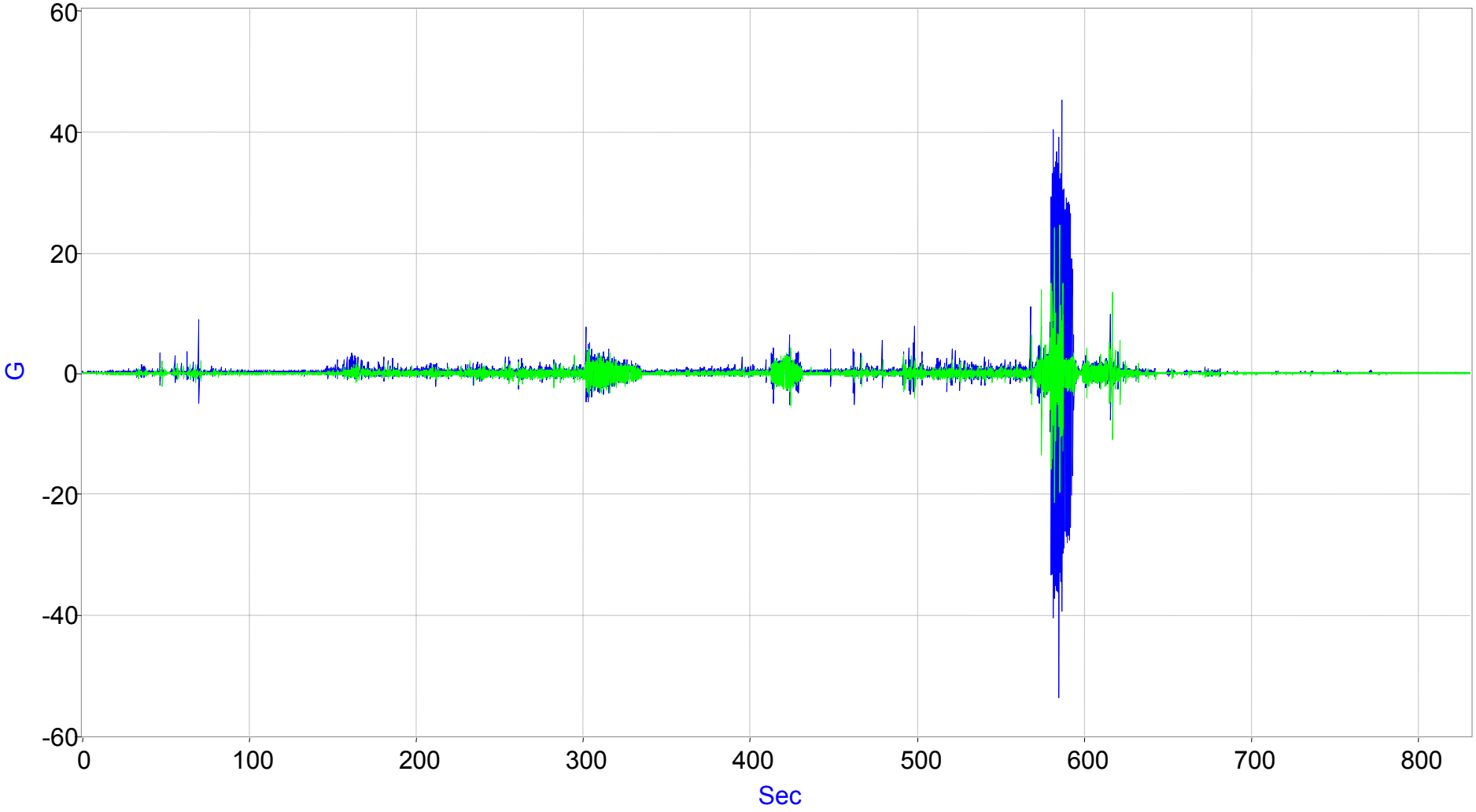


Caliper Accelerations

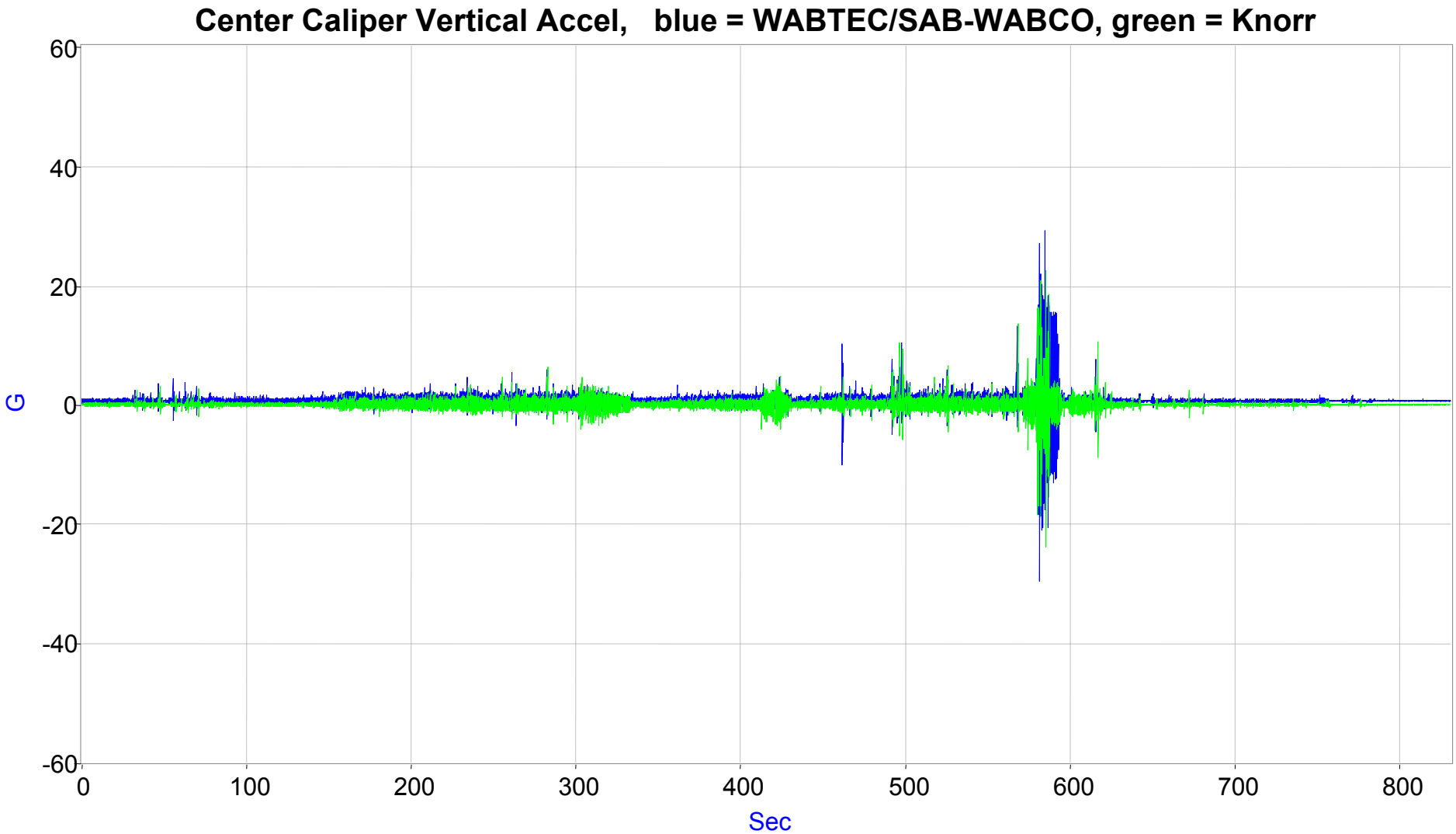
- June 18, 2005 File 24, t = 310 - No BOP, Braking
- June 18, 2005 File 24, t = 581 - BOP, Braking
- June 18, 2005 File 30, t=732 – BOP, Response to Impact

6/18/2005 – File 24

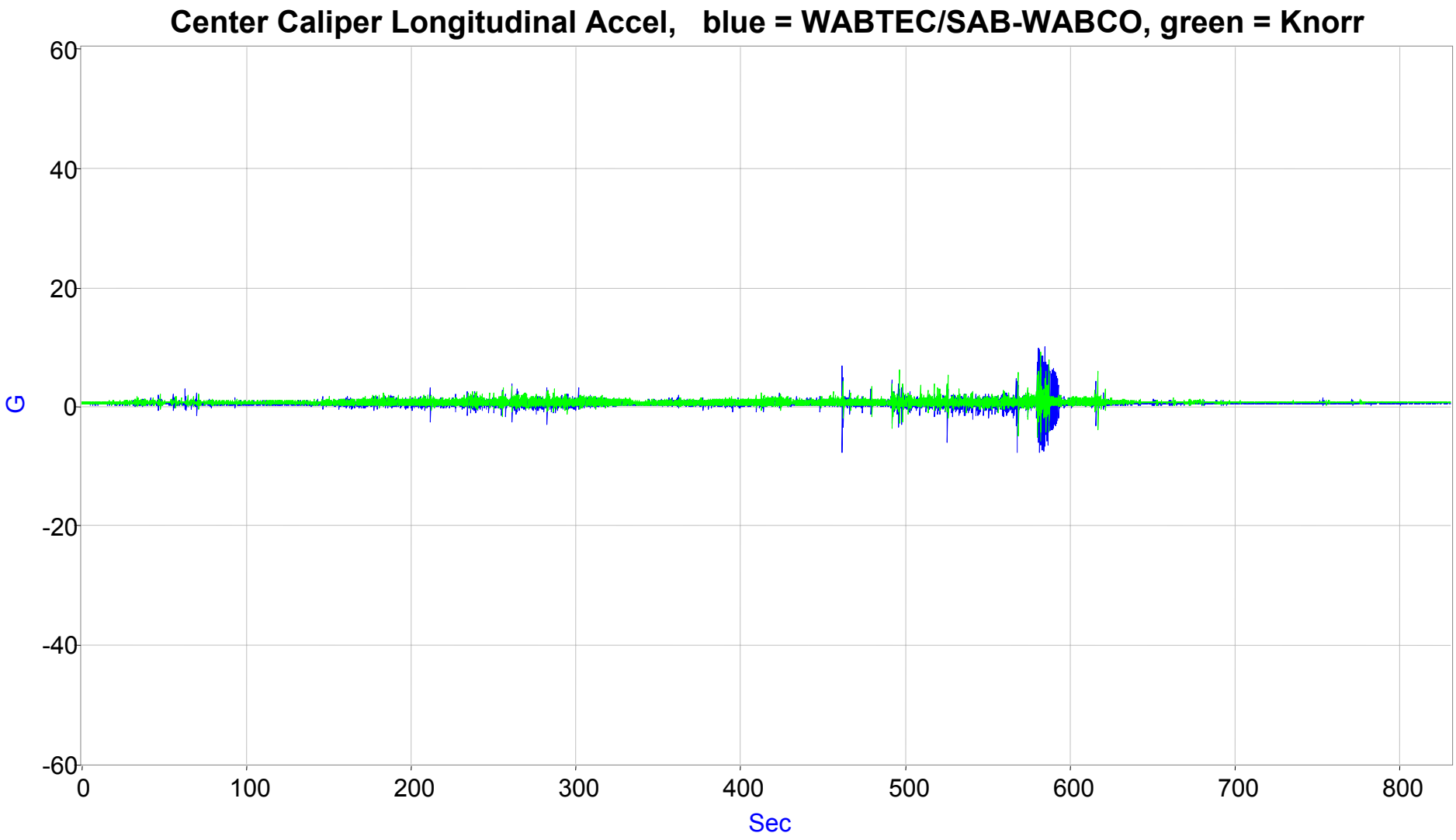
Center Caliper Lateral Accel, blue = WABTEC/SAB-WABCO, green = Knorr



6/18/2005 – File 24

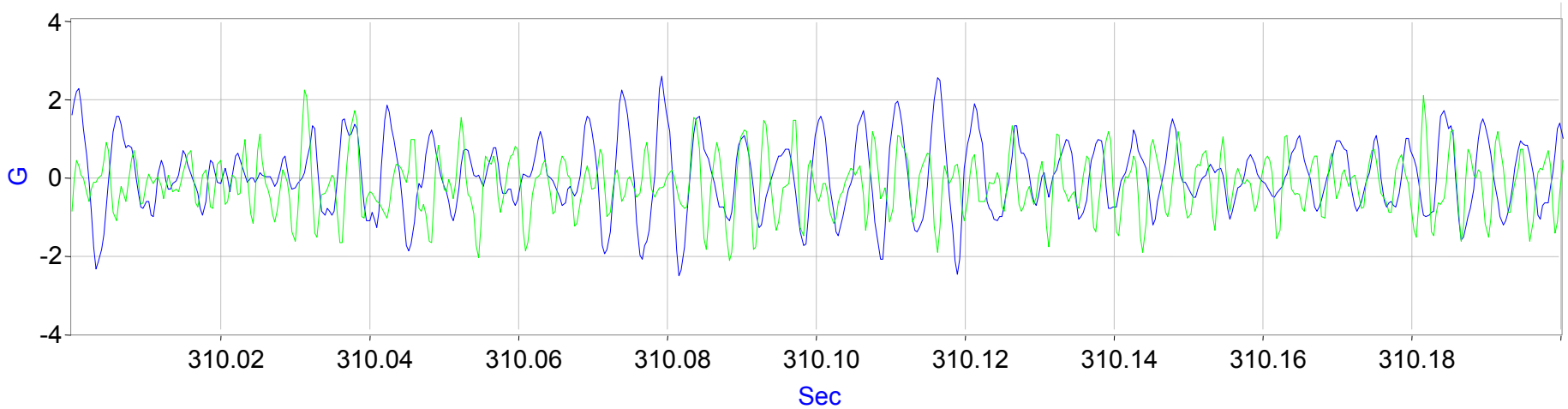


6/18/2005 – File 24

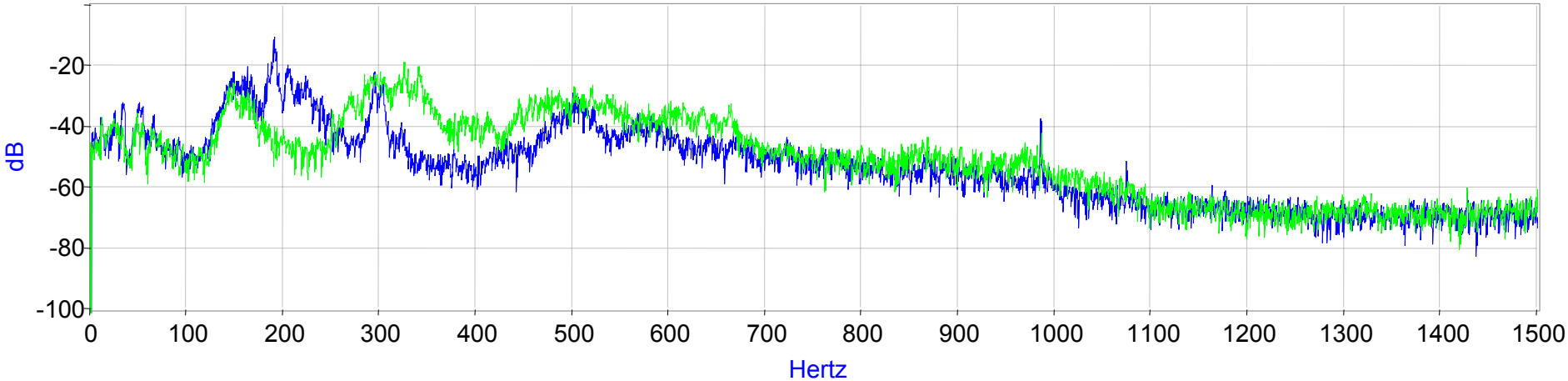


6/18/2005 – File 24 (brake, no SO)

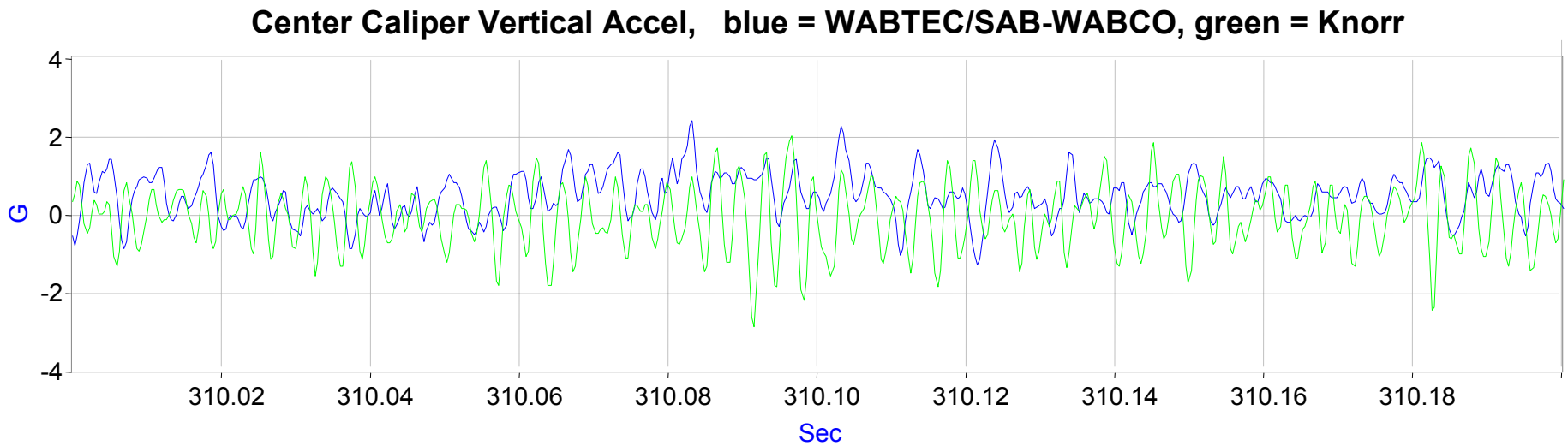
Center Caliper Lateral Accel, blue = WABTEC/SAB-WABCO, green = Knorr

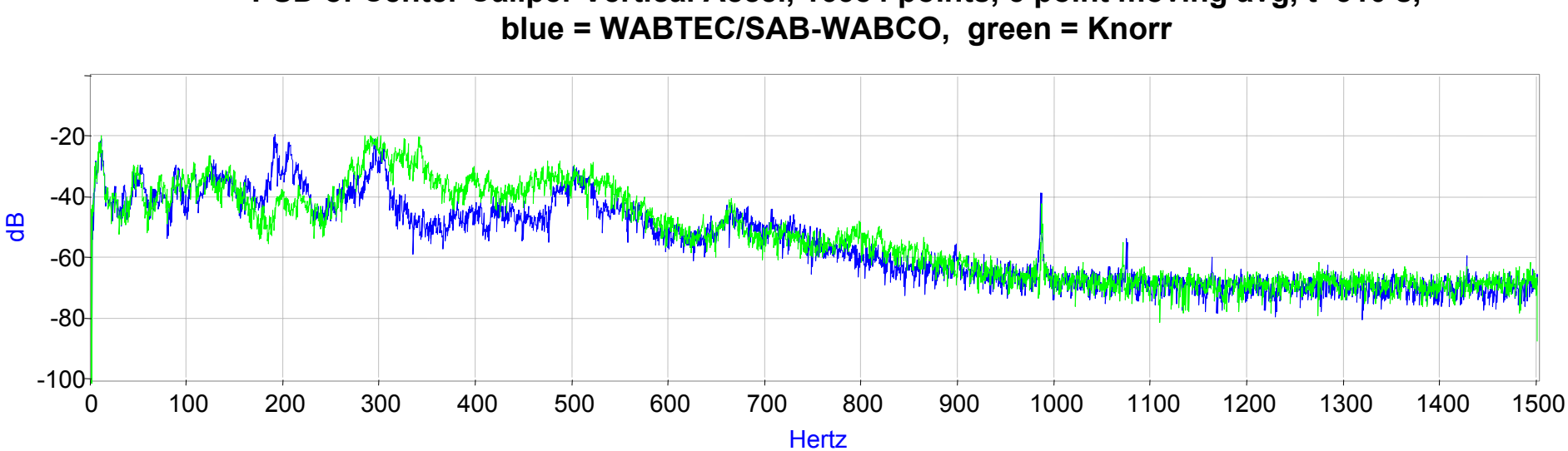


PSD of Center Caliper Lateral Accel, 16384 points, 5 point moving avg, t=310 s, blue = WABTEC/SAB-WABCO, green = Knorr



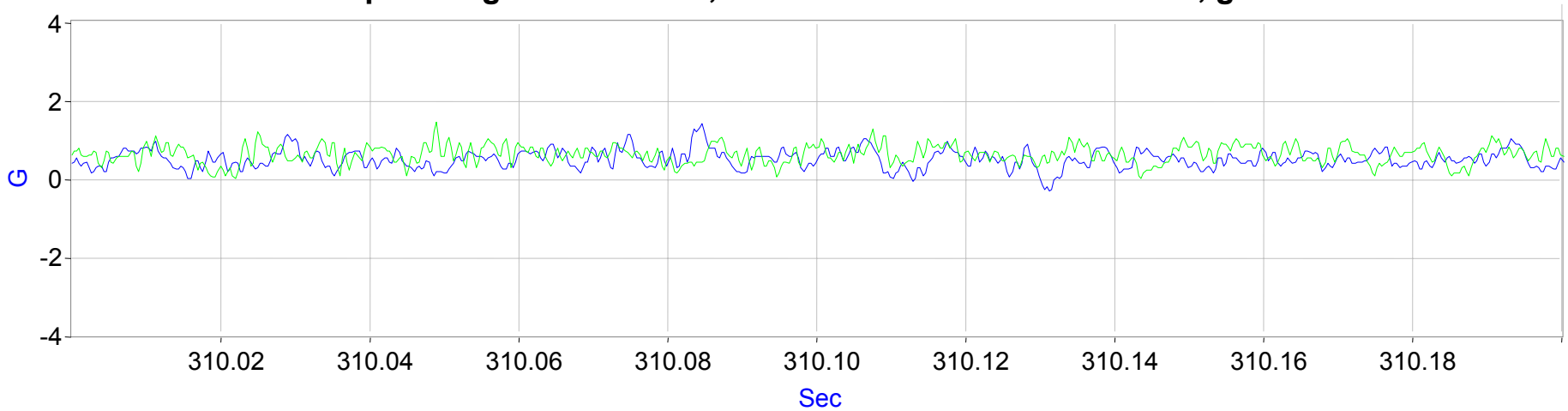
6/18/2005 – File 24 (brake, no SO)



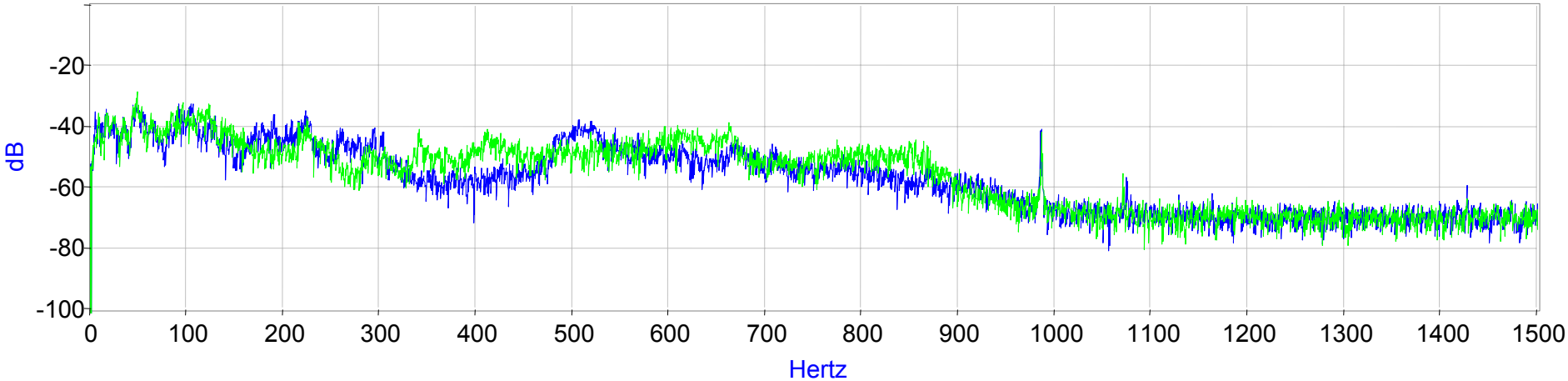


6/18/2005 – File 24 (brake, no SO)

Center Caliper Longitudinal Accel, blue = WABTEC/SAB-WABCO, green = Knorr

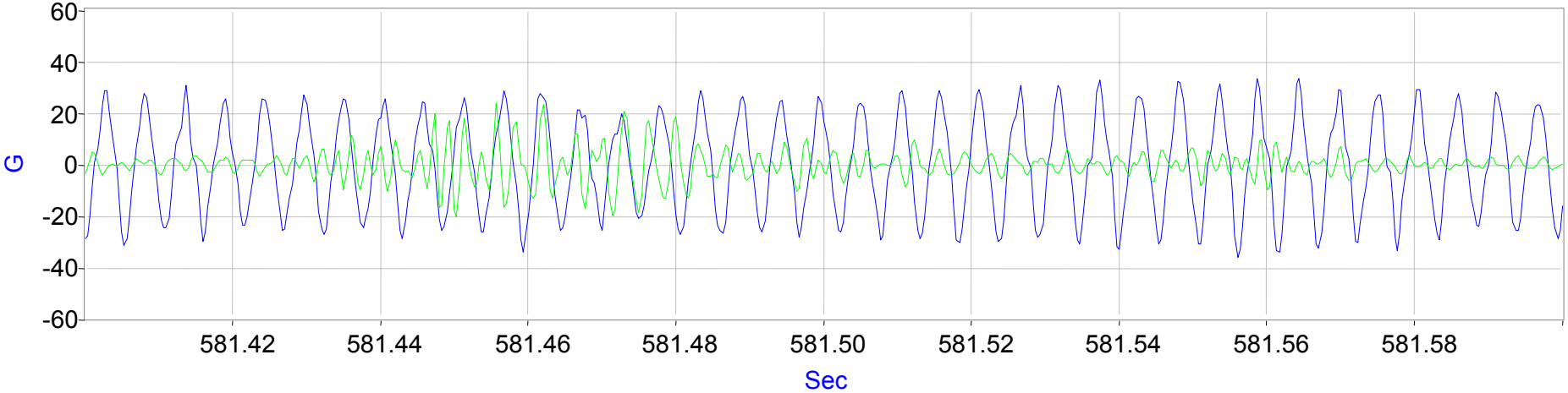


PSD of Center Caliper Longitudinal Accel, 16384 points, 5 point moving avg, t=310 s, blue = WABTEC/SAB-WABCO, green = Kno

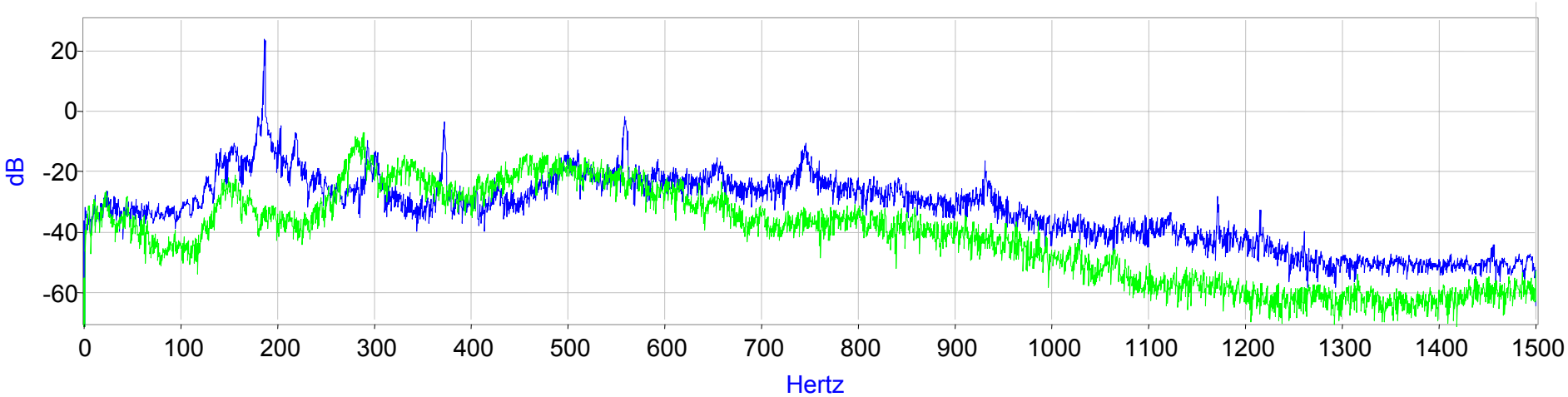


6/18/2005 – File 24 (brake, SO)

Center Caliper Lateral Accel, blue = WABTEC/SAB-WABCO, green = Knorr

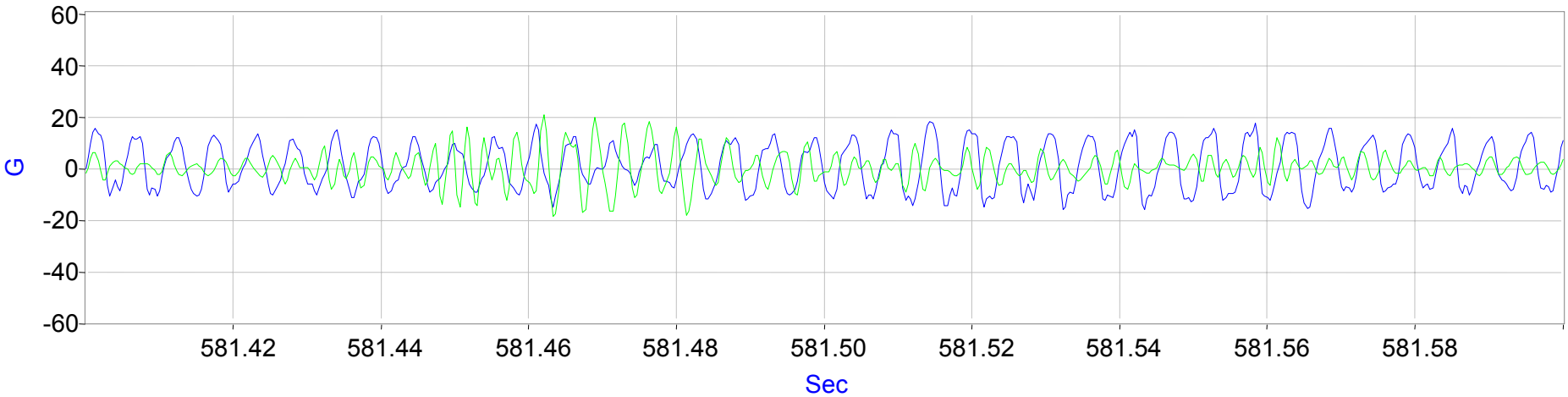


PSD of Center Caliper Lateral Accel, 16384 points, 5 point moving avg, t=581 s, blue = WABTEC/SAB-WABCO, green = Knorr

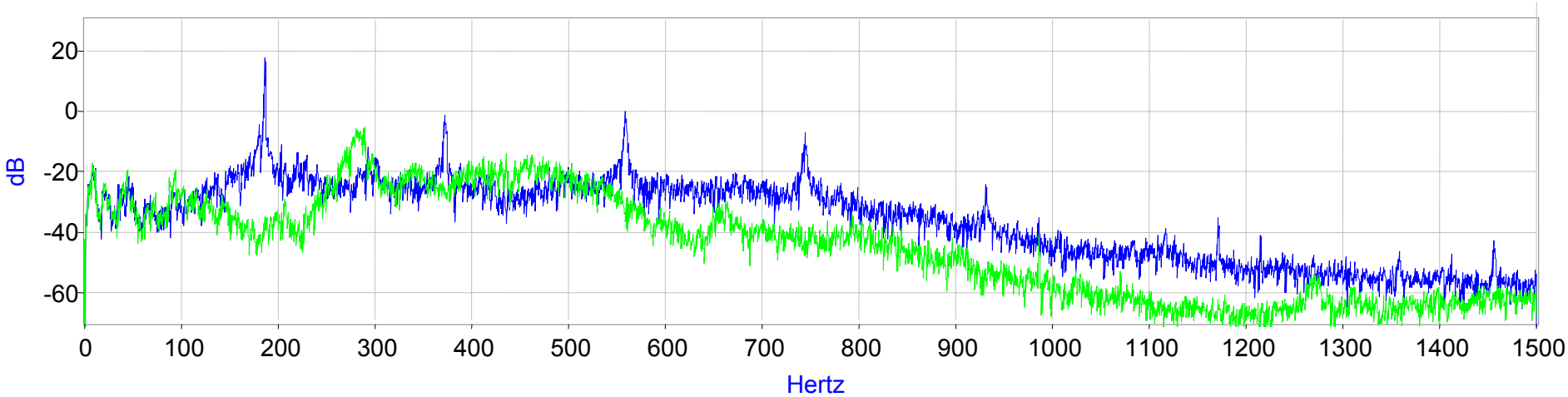


6/18/2005 – File 24 (brake, SO)

Center Caliper Vertical Accel, blue = WABTEC/SAB-WABCO, green = Knorr

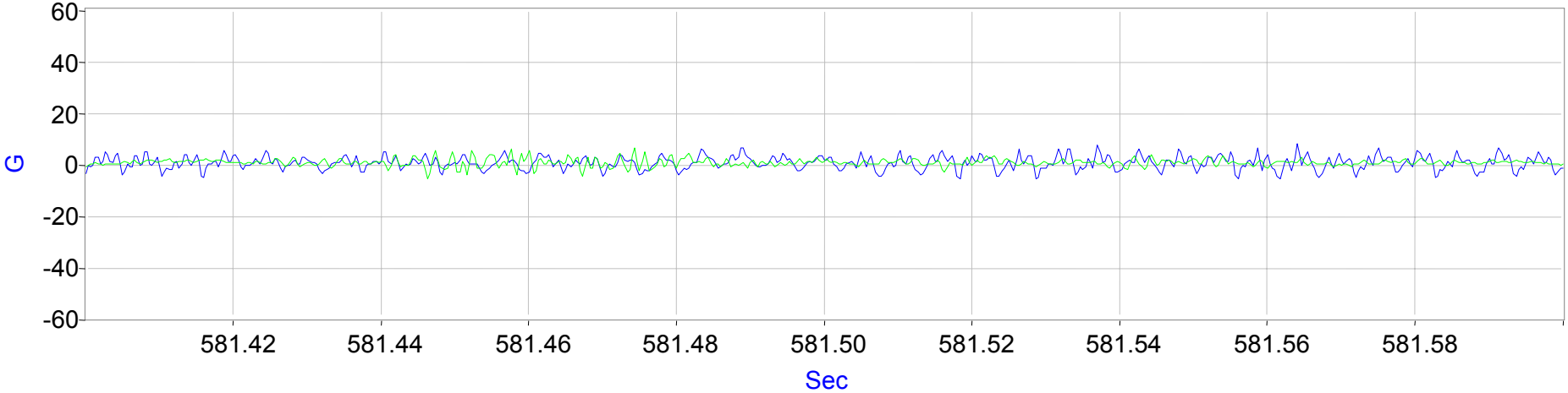


PSD of Center Caliper Vertical Accel, 16384 points, 5 point moving avg, t=581 s, blue = WABTEC/SAB-WABCO, green = Knorr

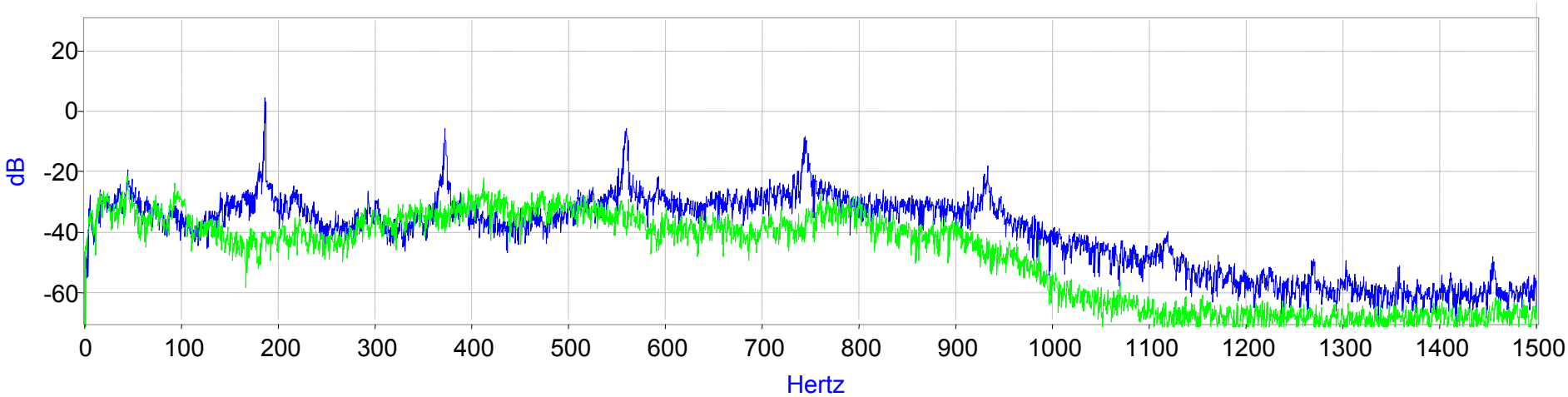


6/18/2005 – File 24 (brake, SO)

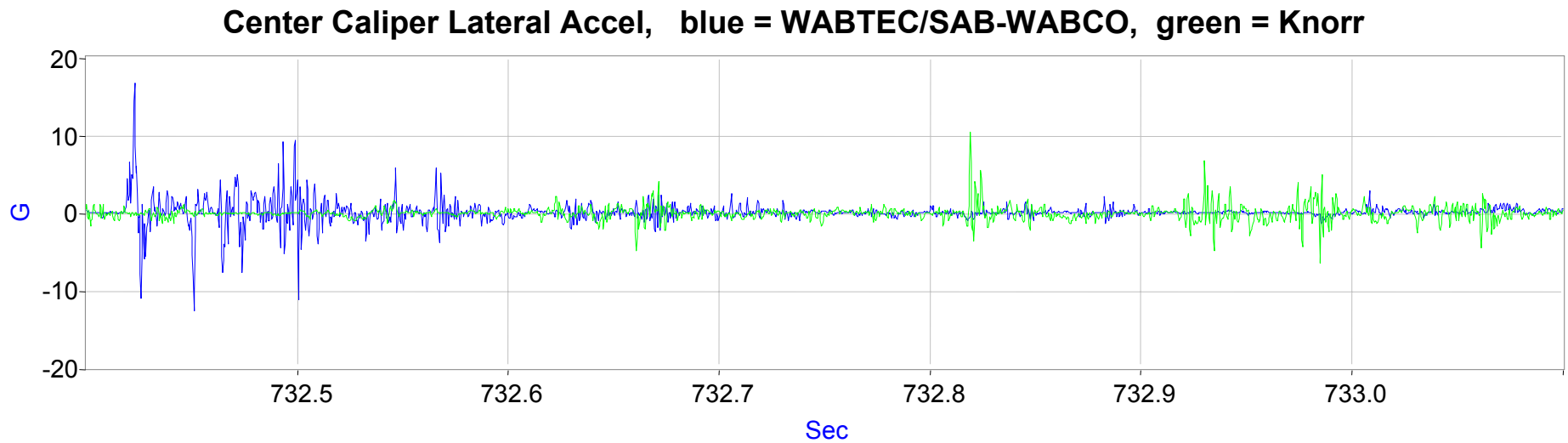
Center Caliper Longitudinal Accel, blue = WABTEC/SAB-WABCO, green = Knorr

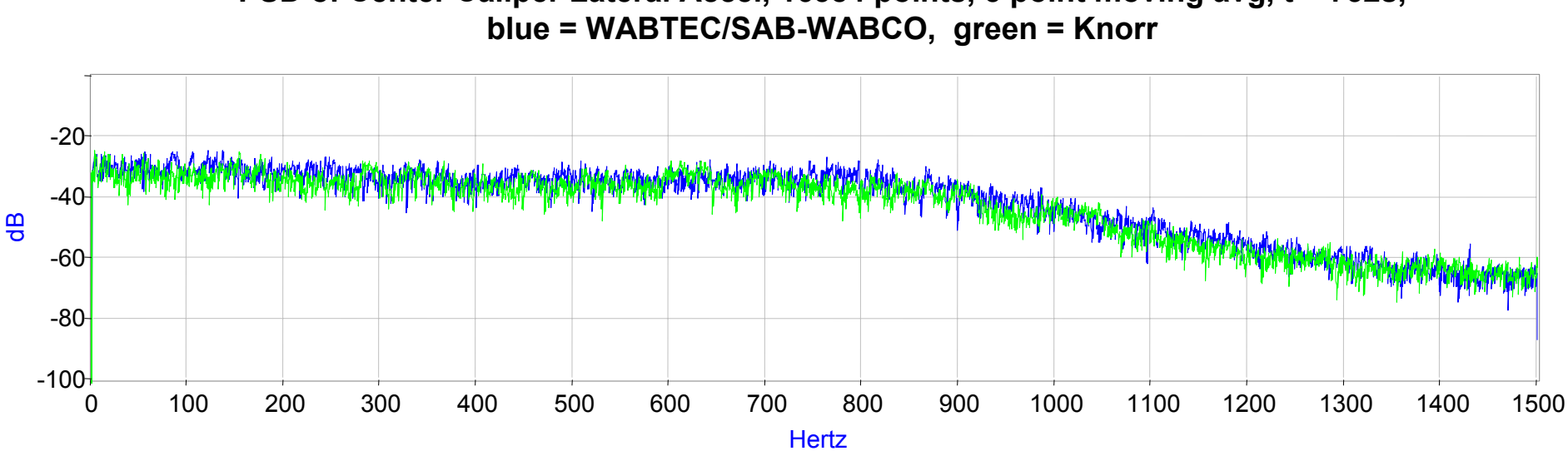


PSD of Center Caliper Longitudinal Accel, 16384 points, 5 point moving avg, t=581 s, blue = WABTEC/SAB-WABCO, green = Knorr



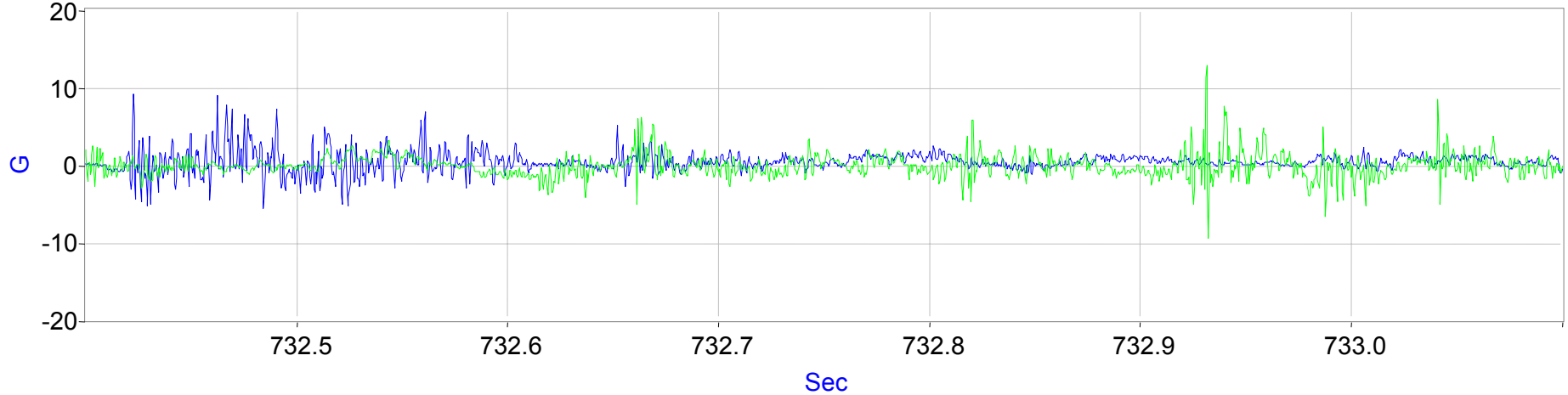
6/18/2005 – File 30 (no brake)



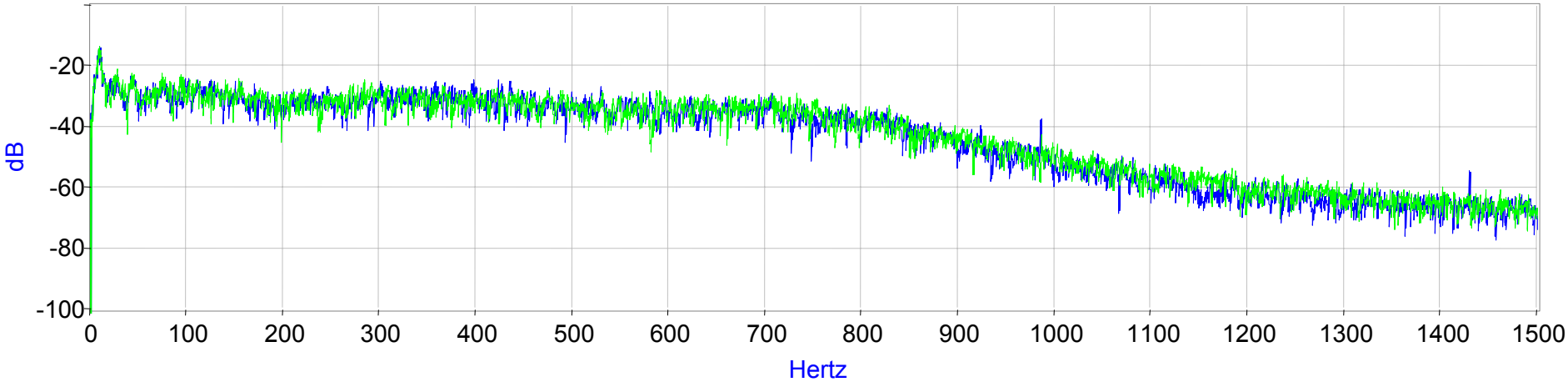


6/18/2005 – File 30 (no brake)

Center Caliper Vertical Accel, blue = WABTEC/SAB-WABCO, green = Knorr

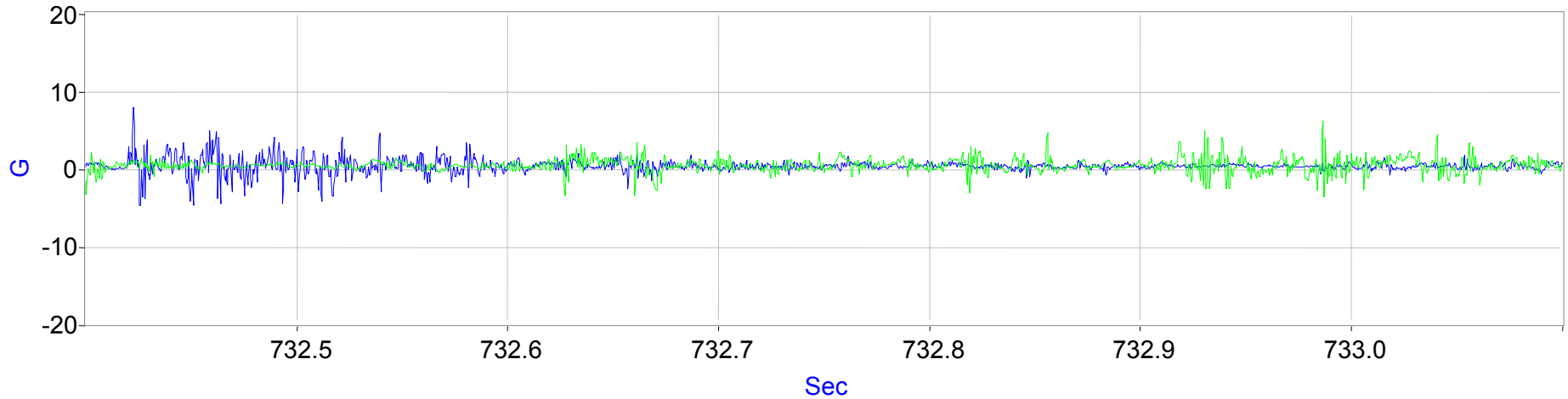


PSD of Center Caliper Vertical Accel, 16384 points, 5 point moving avg, t = 732s, blue = WABTEC/SAB-WABCO, green = Knorr

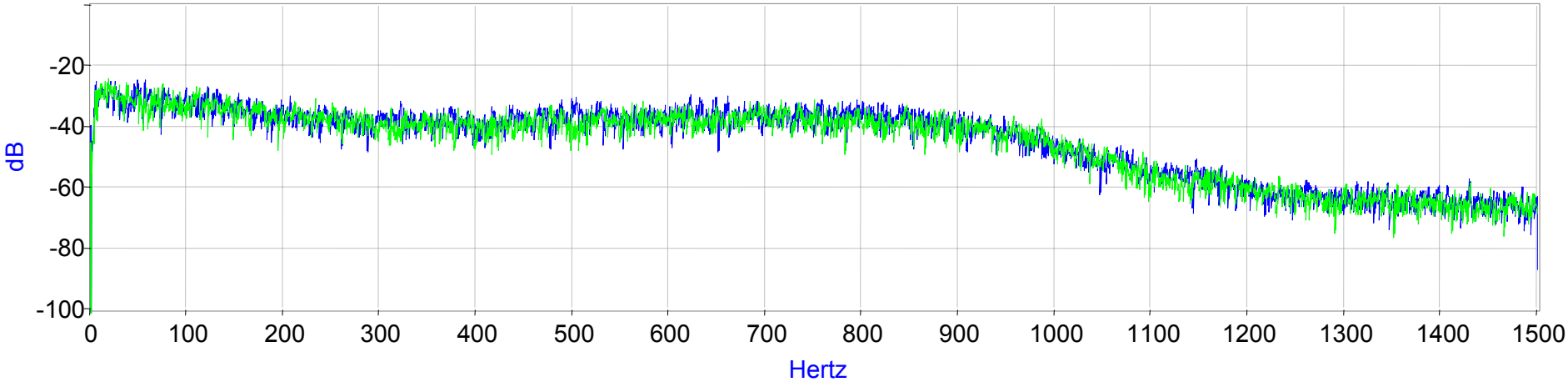


6/18/2005 – File 30 (no brake)

Center Caliper Longitudinal Accel, blue = WABTEC/SAB-WABCO, green = Knorr



PSD of Center Caliper Longitudinal Accel, 16384 points, 5 point moving avg, t = 732s, blue = WABTEC/SAB-WABCO, green = Knorr

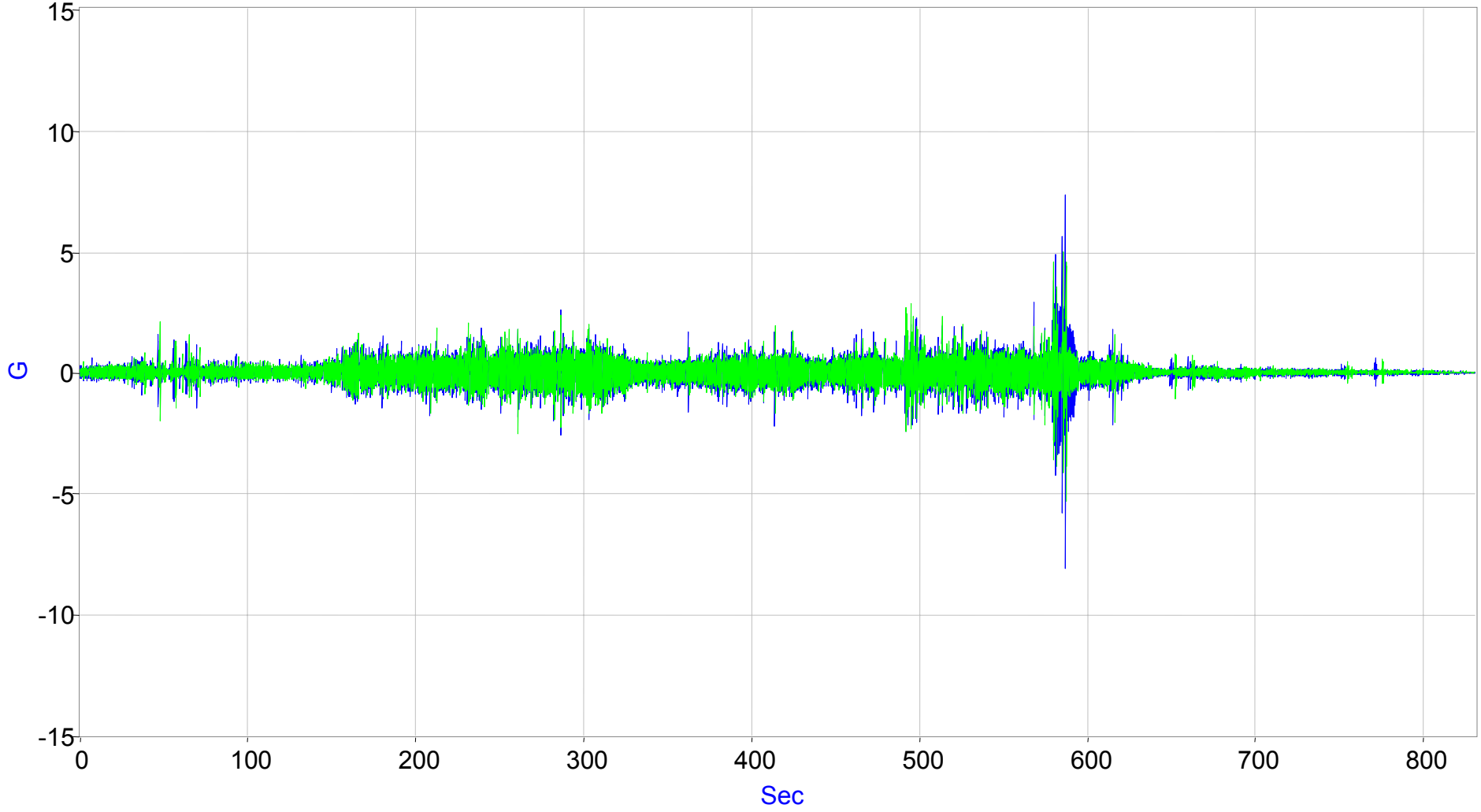


Brake Mount Accelerations

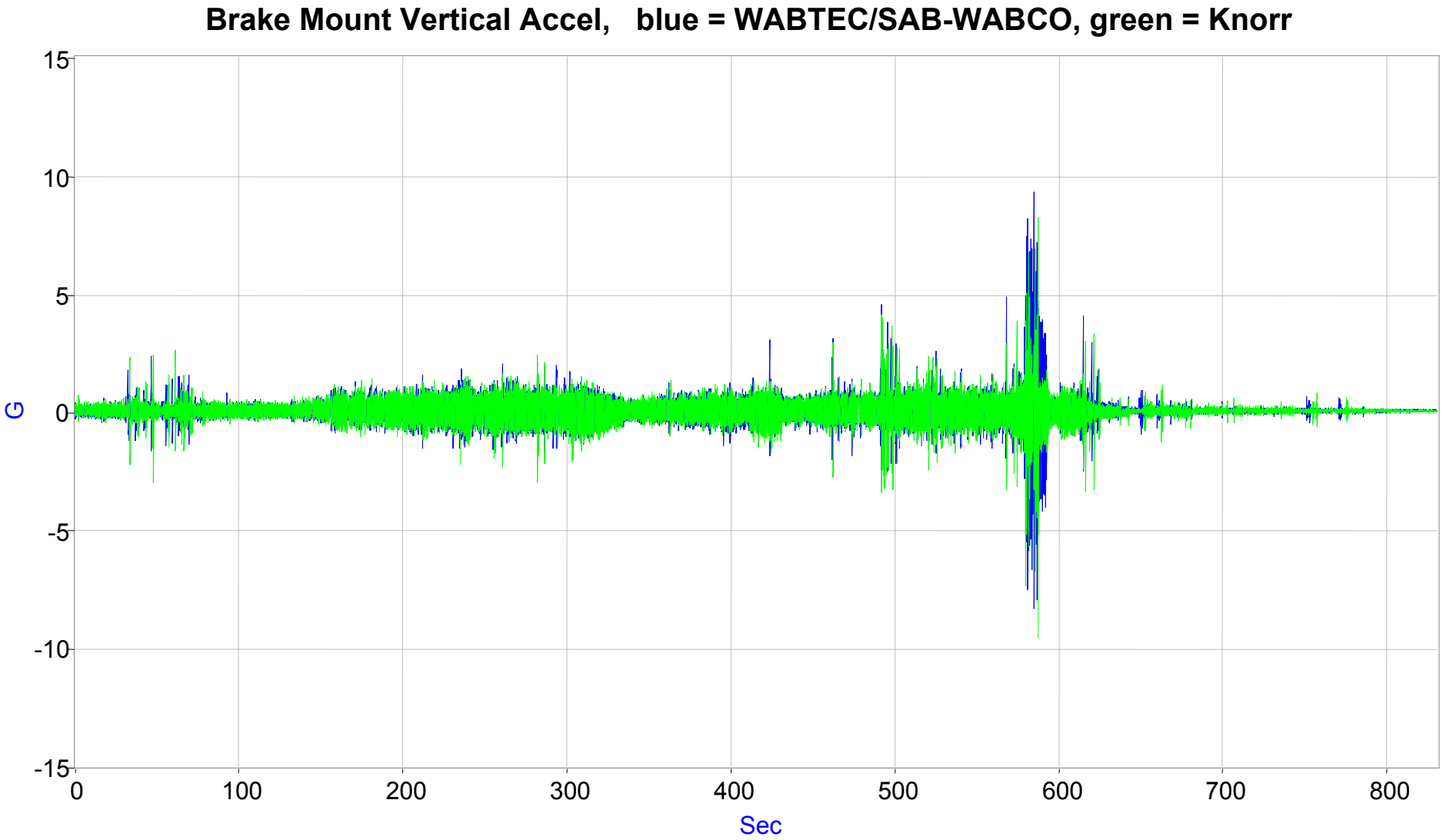
- June 18, 2005 File 24, t = 310 - No BOP, Braking
- June 18, 2005 File 24, t = 581 - BOP, Braking
- June 18, 2005 File 30, t=732 – BOP, Response to Impact

6/18/2005 – File 24

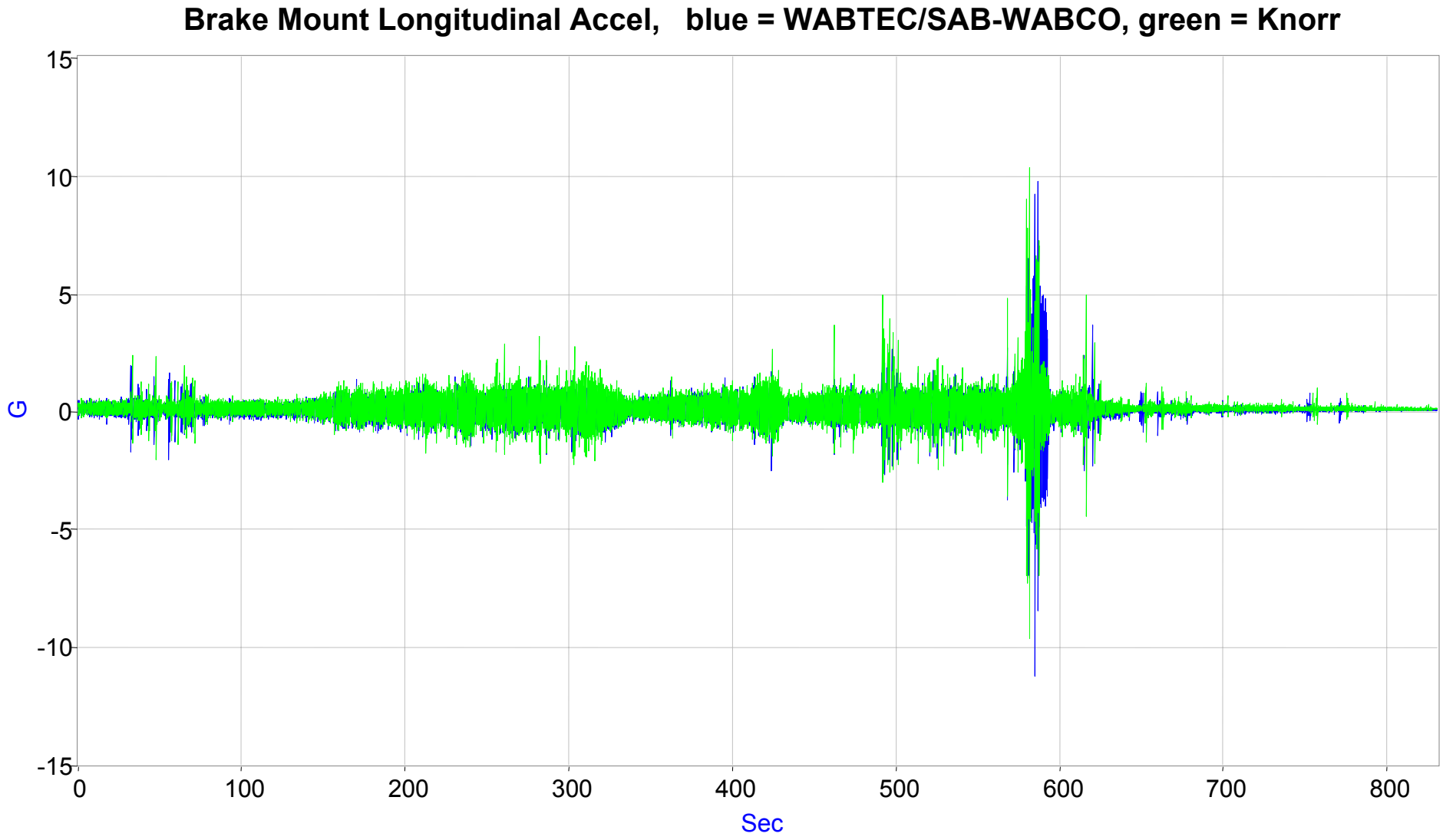
Brake Mount Lateral Accel, blue = WABTEC/SAB-WABCO, green = Knorr



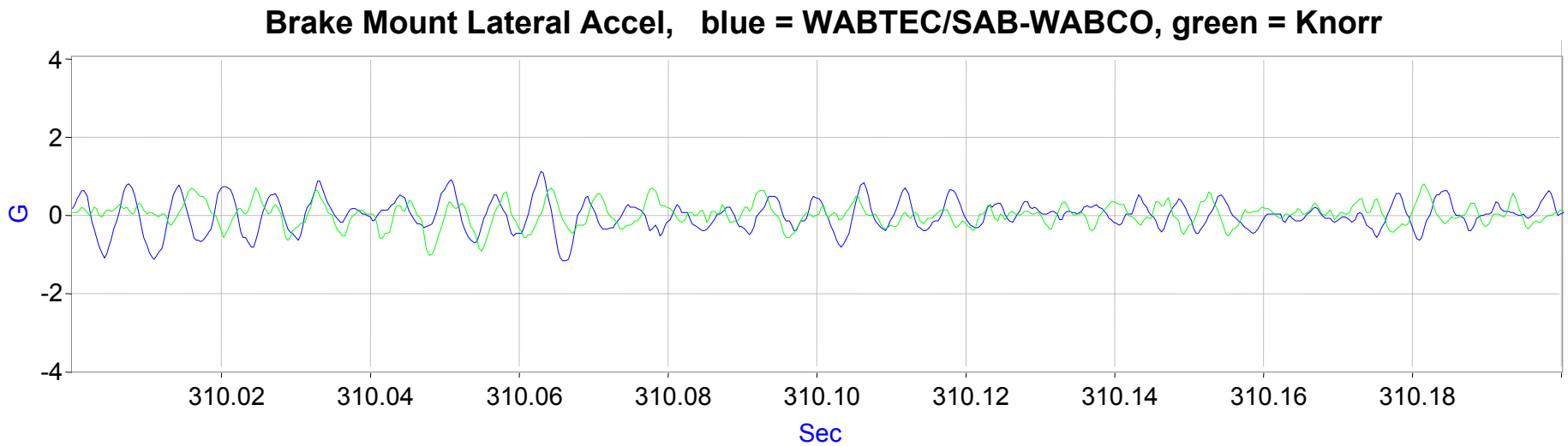
6/18/2005 – File 24

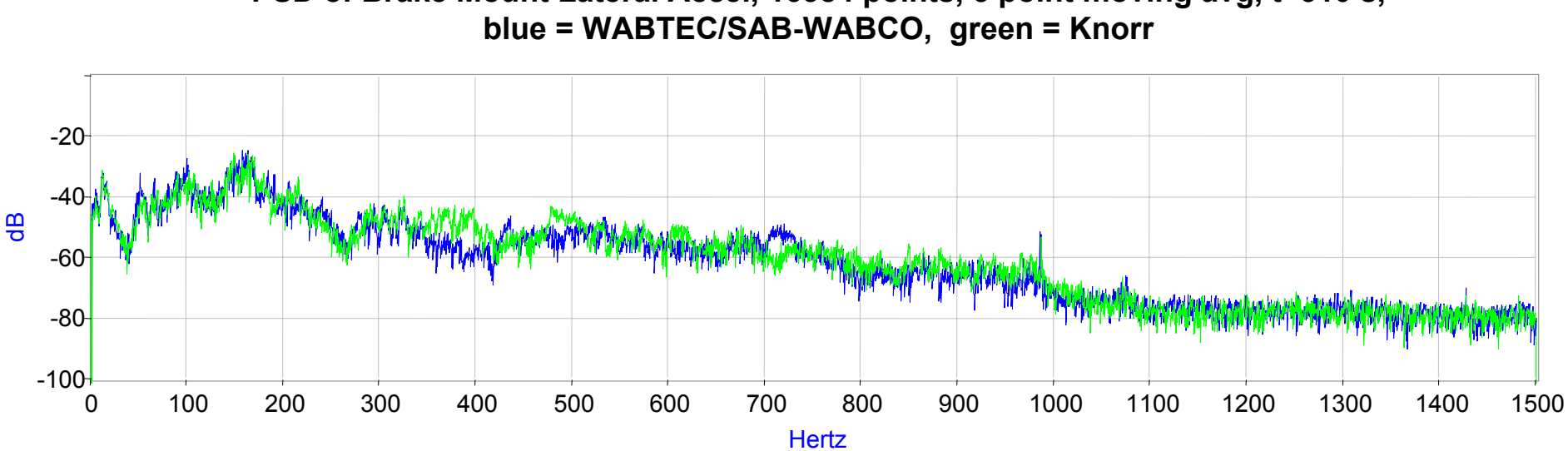


6/18/2005 – File 24

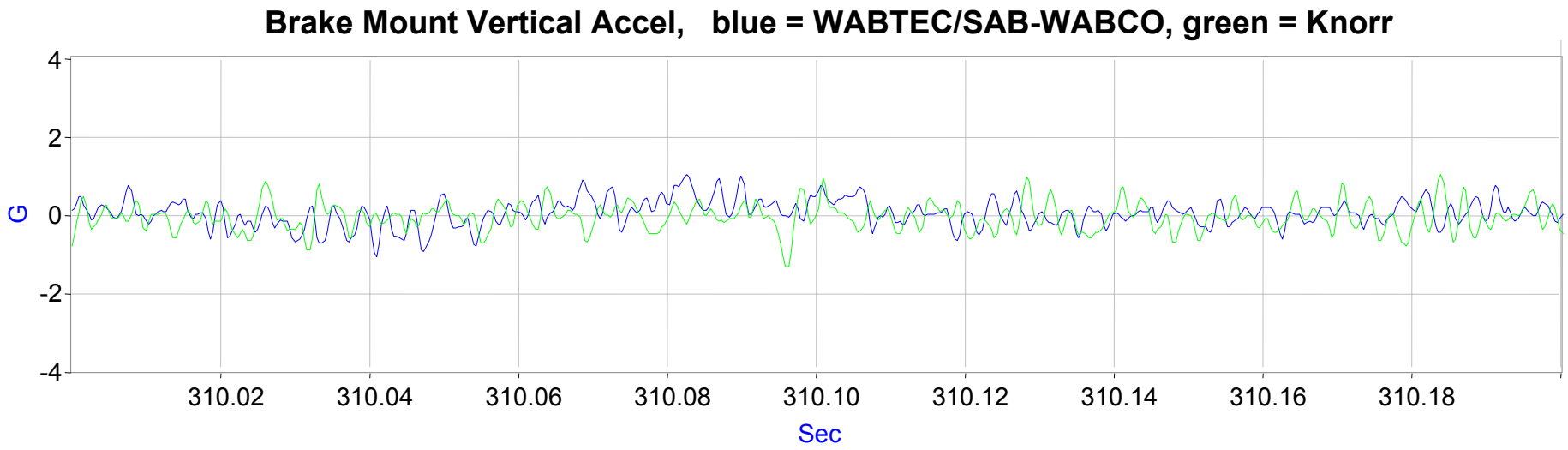


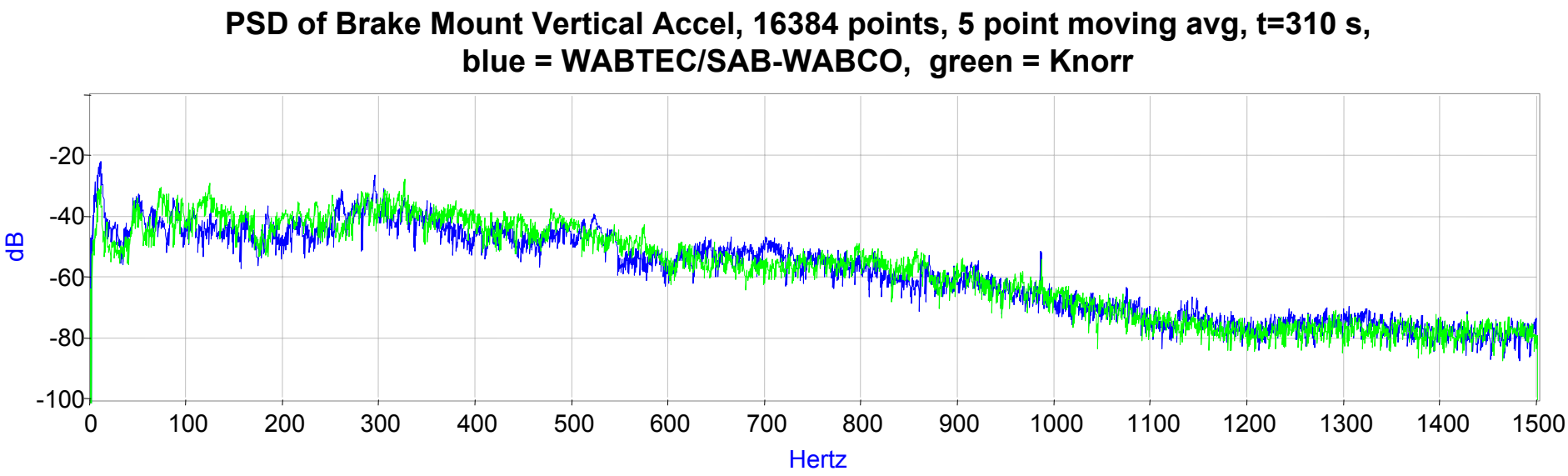
6/18/2005 – File 24 (brake, no SO)



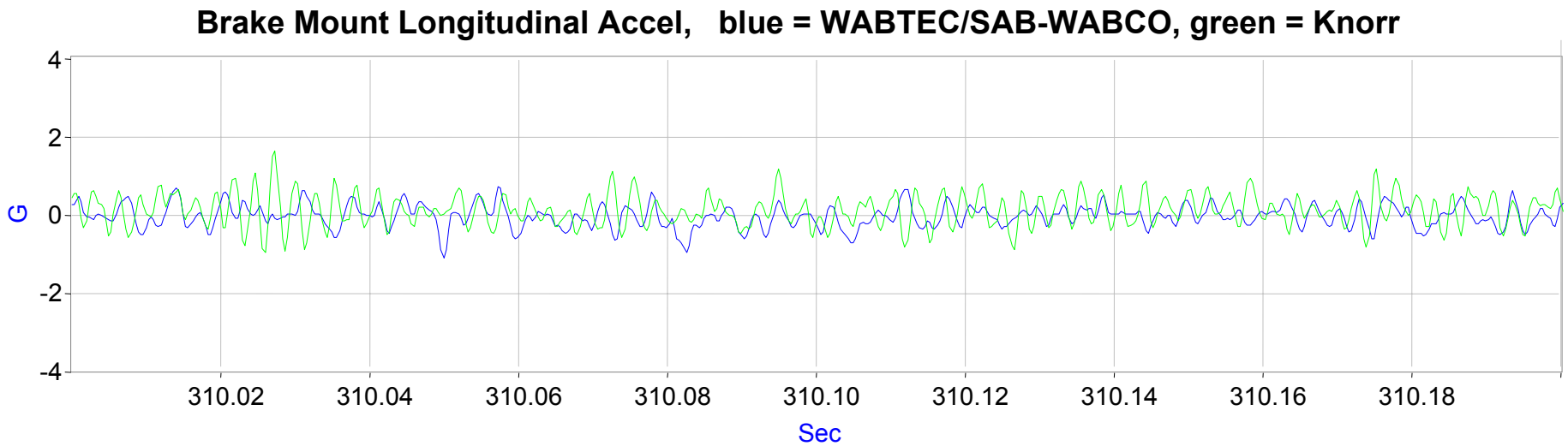


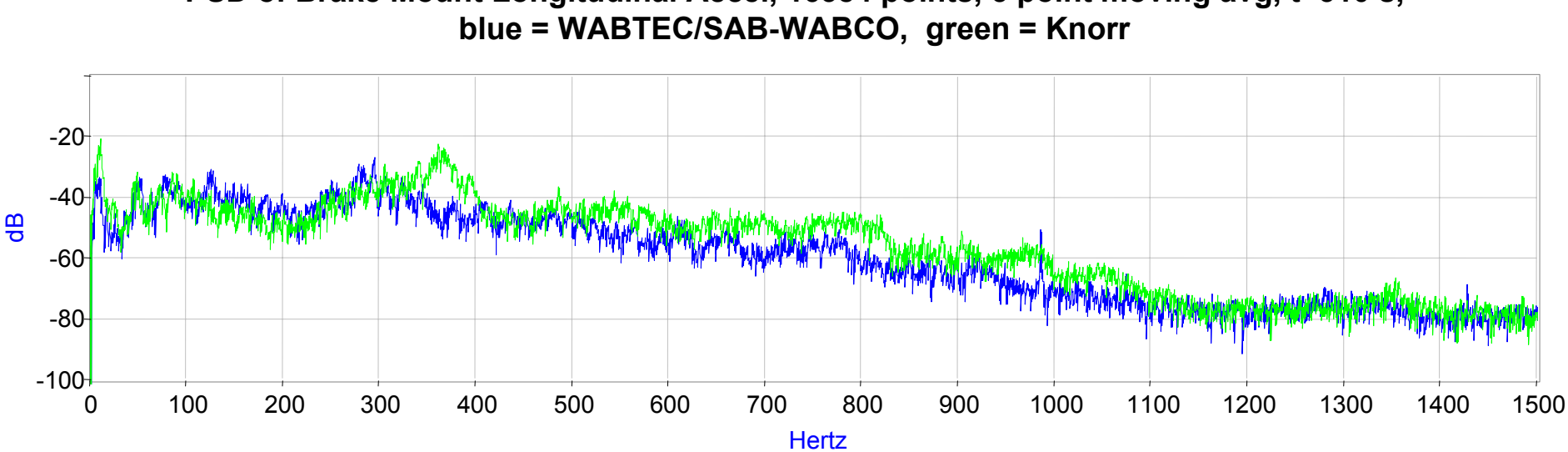
6/18/2005 – File 24 (brake, no SO)



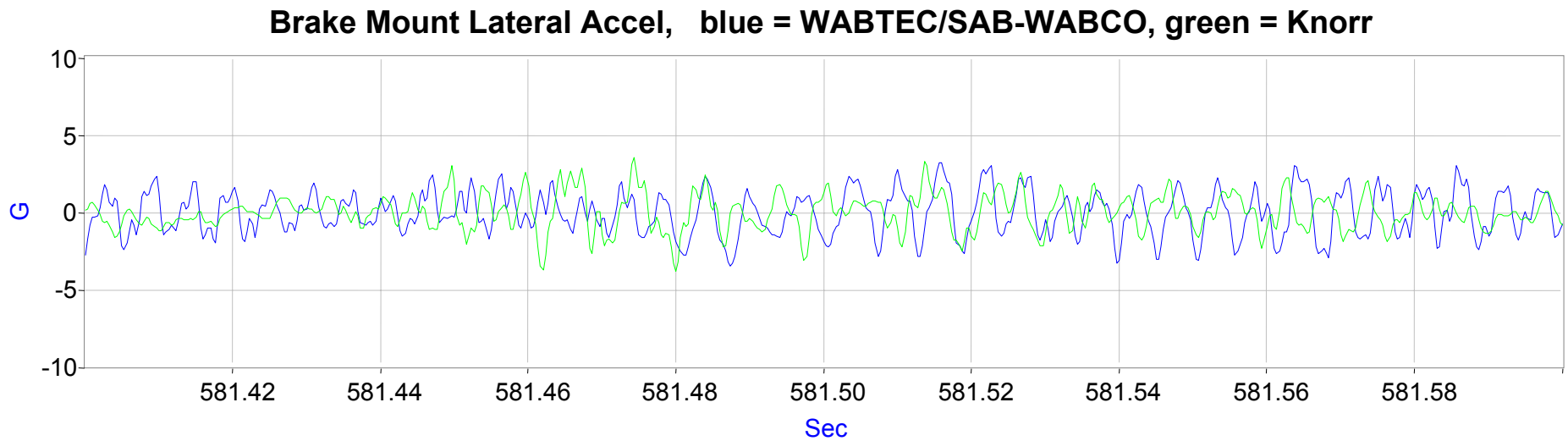


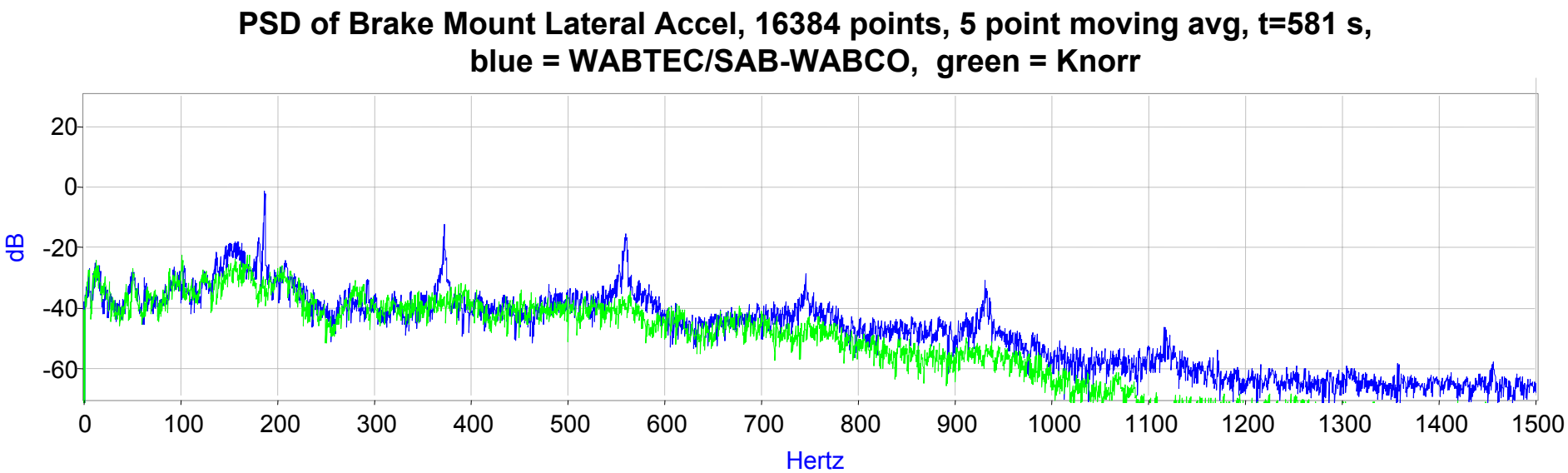
6/18/2005 – File 24 (brake, no SO)





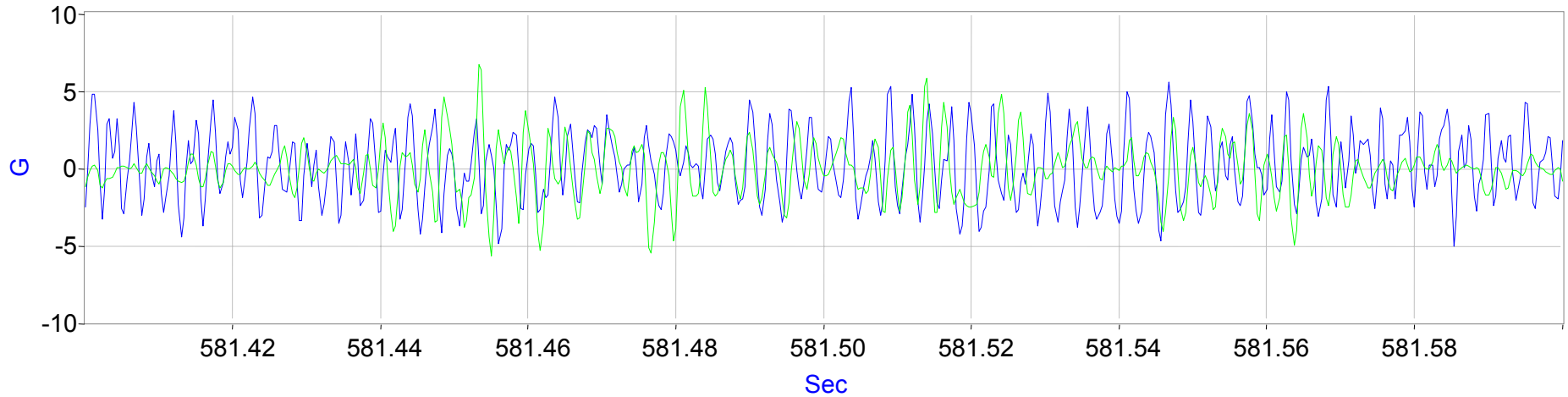
6/18/2005 – File 24 (brake, SO)



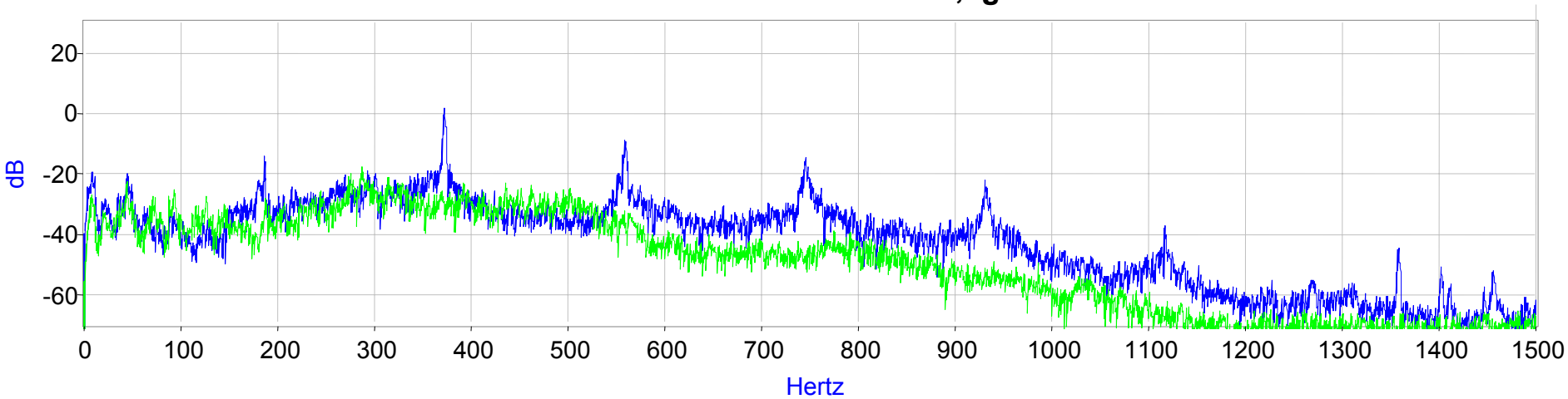


6/18/2005 – File 24 (brake, SO)

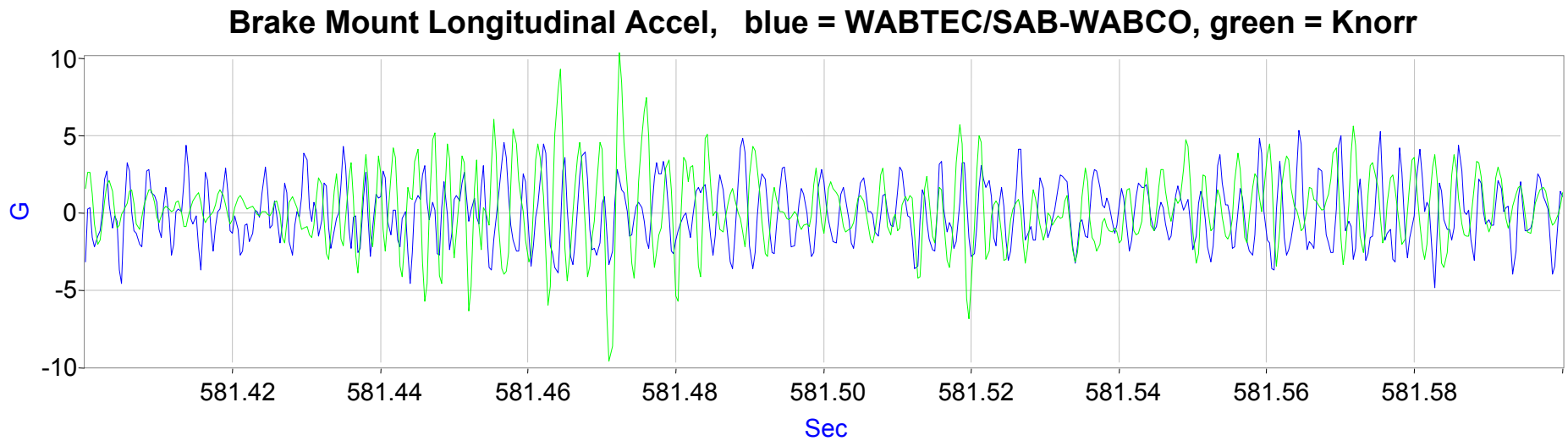
Brake Mount Vertical Accel, blue = WABTEC/SAB-WABCO, green = Knorr

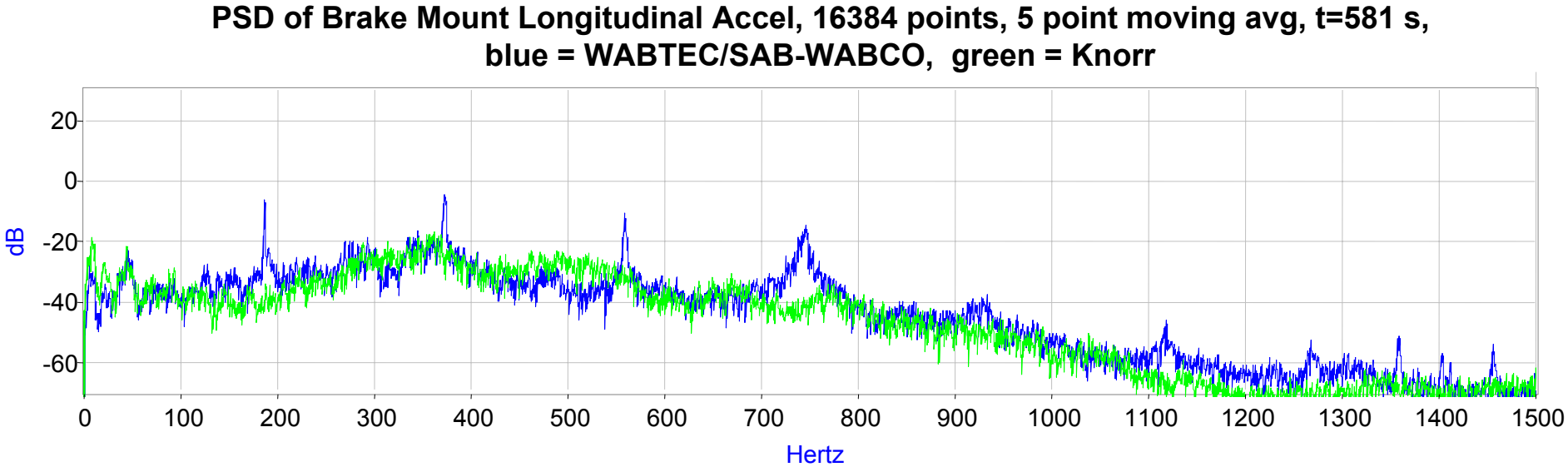


PSD of Brake Mount Vertical Accel, 16384 points, 5 point moving avg, t=581 s, blue = WABTEC/SAB-WABCO, green = Knorr



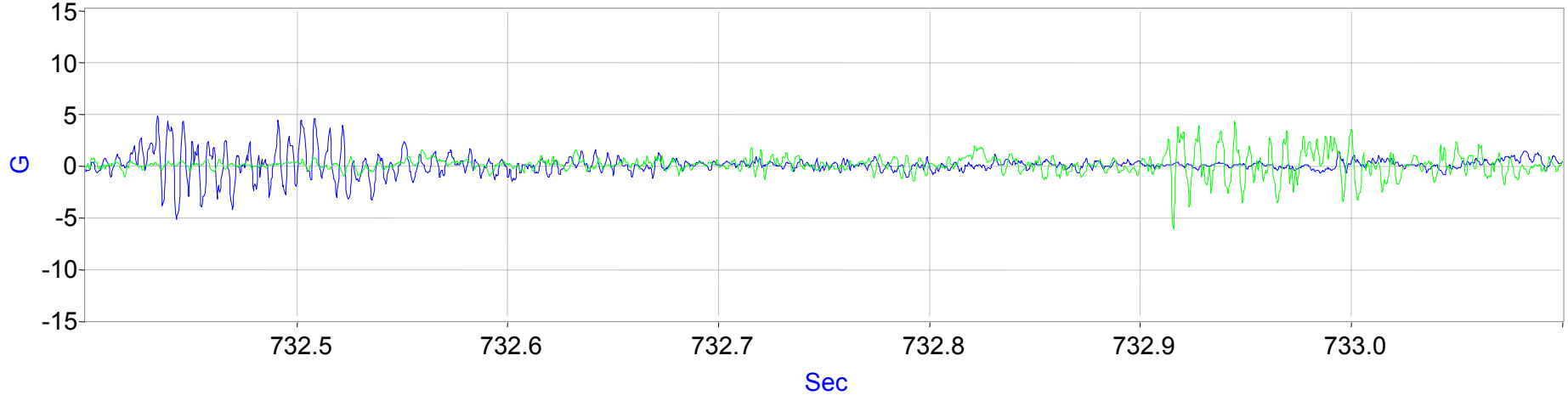
6/18/2005 – File 24 (brake, SO)



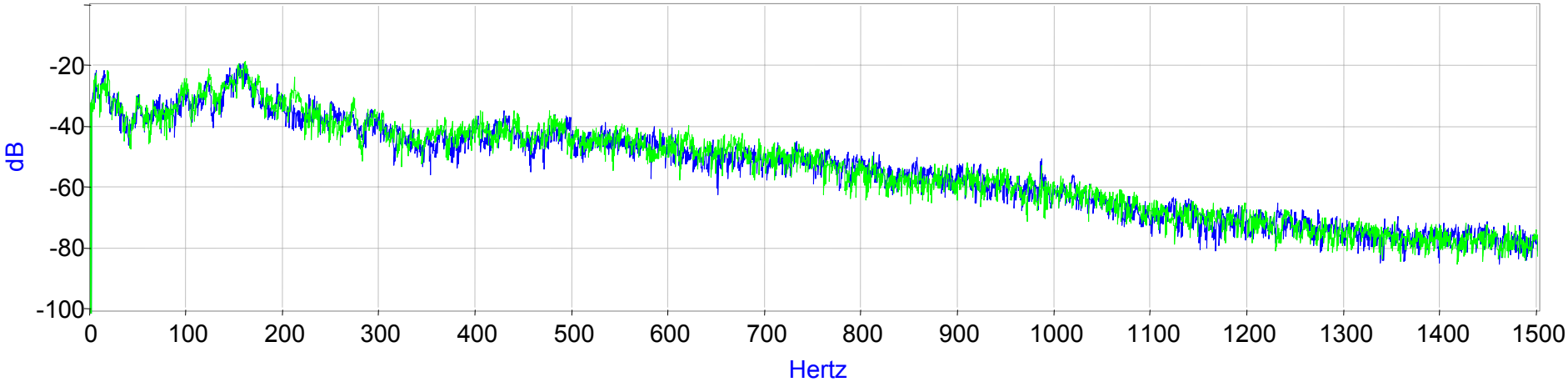


6/18/2005 – File 30 (no brake)

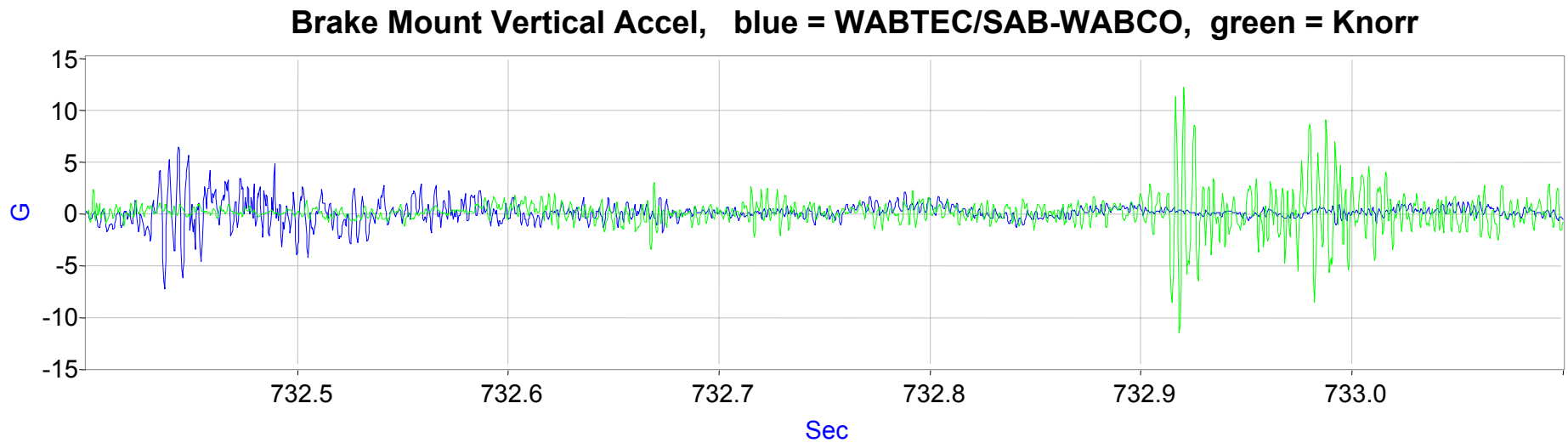
Brake Mount Lateral Accel, blue = WABTEC/SAB-WABCO, green = Knorr

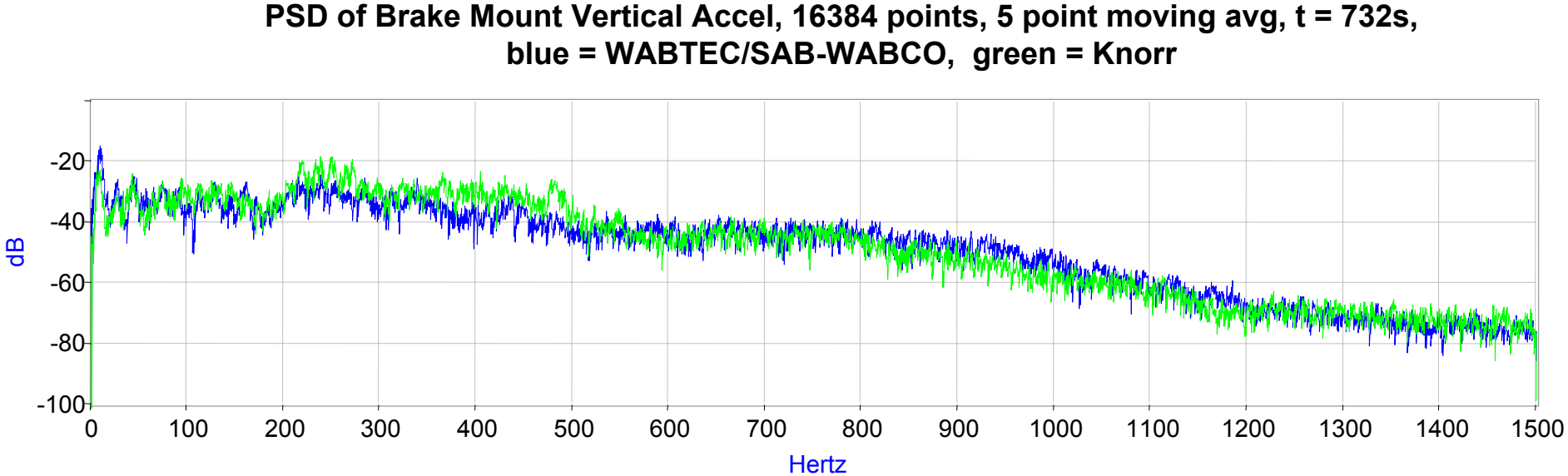


PSD of Brake Mount Lateral Accel, 16384 points, 5 point moving avg, t = 732s, blue = WABTEC/SAB-WABCO, green = Knorr



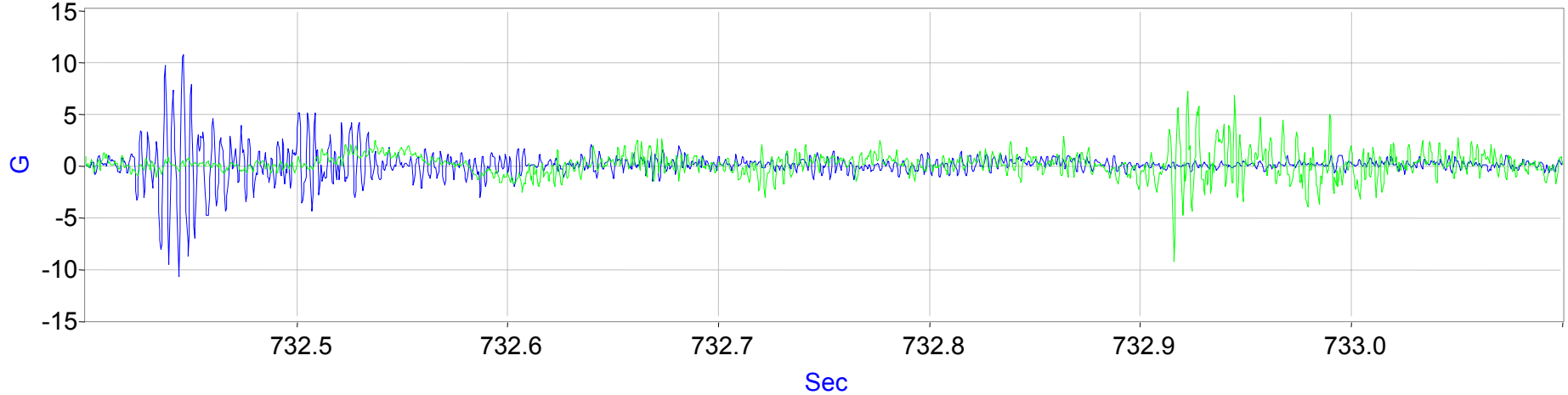
6/18/2005 – File 30 (no brake)



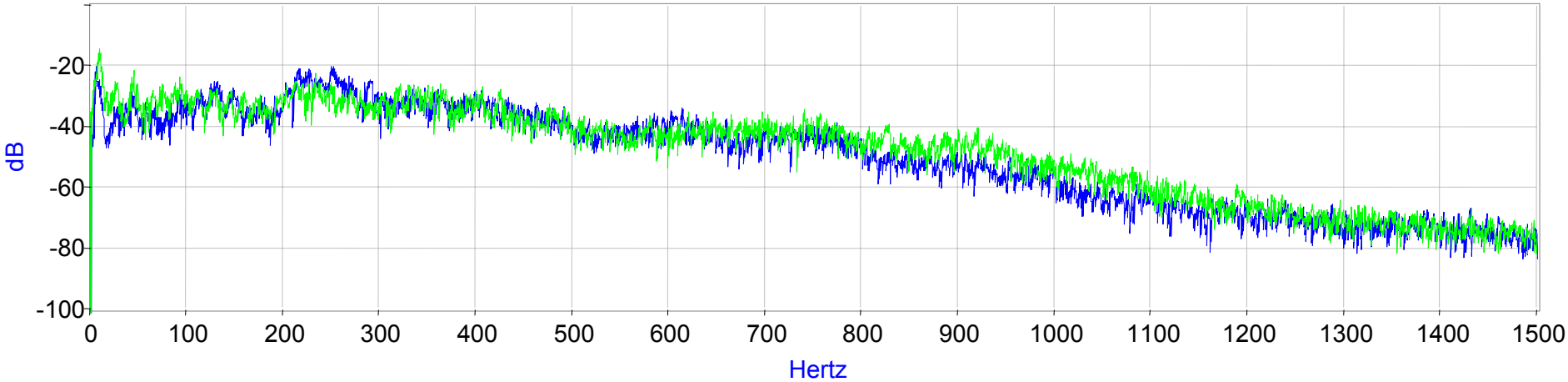


6/18/2005 – File 30 (no brake)

Brake Mount Longitudinal Accel, blue = WABTEC/SAB-WABCO, green = Knorr



PSD of Brake Mount Longitudinal Accel, 16384 points, 5 point moving avg, t = 732s, blue = WABTEC/SAB-WABCO, green = Knorr

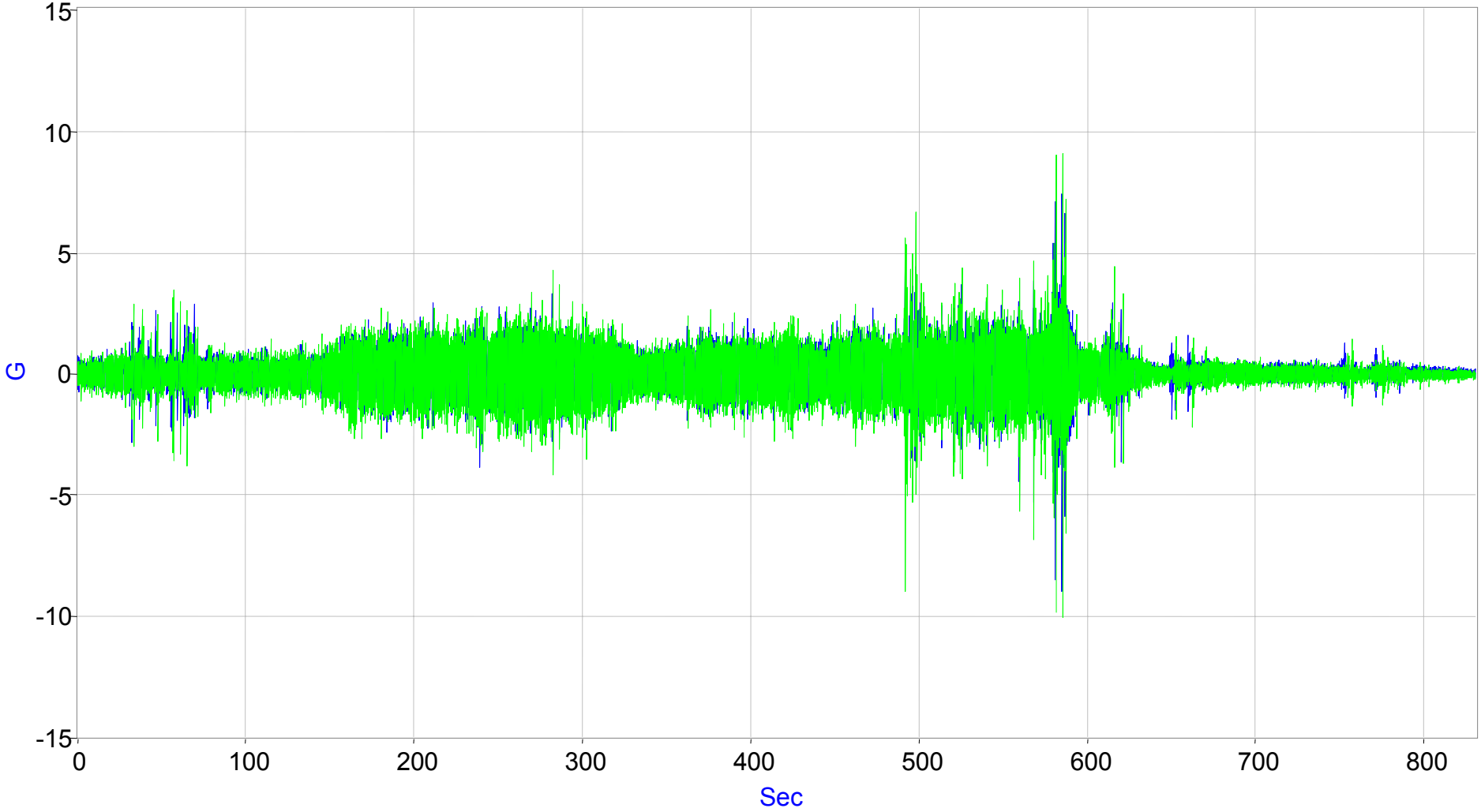


Truck Accelerations

- June 18, 2005 File 24, t = 310 - No BOP, Braking
- June 18, 2005 File 24, t = 581 - BOP, Braking
- June 18, 2005 File 30, t=732 – BOP, Response to Impact

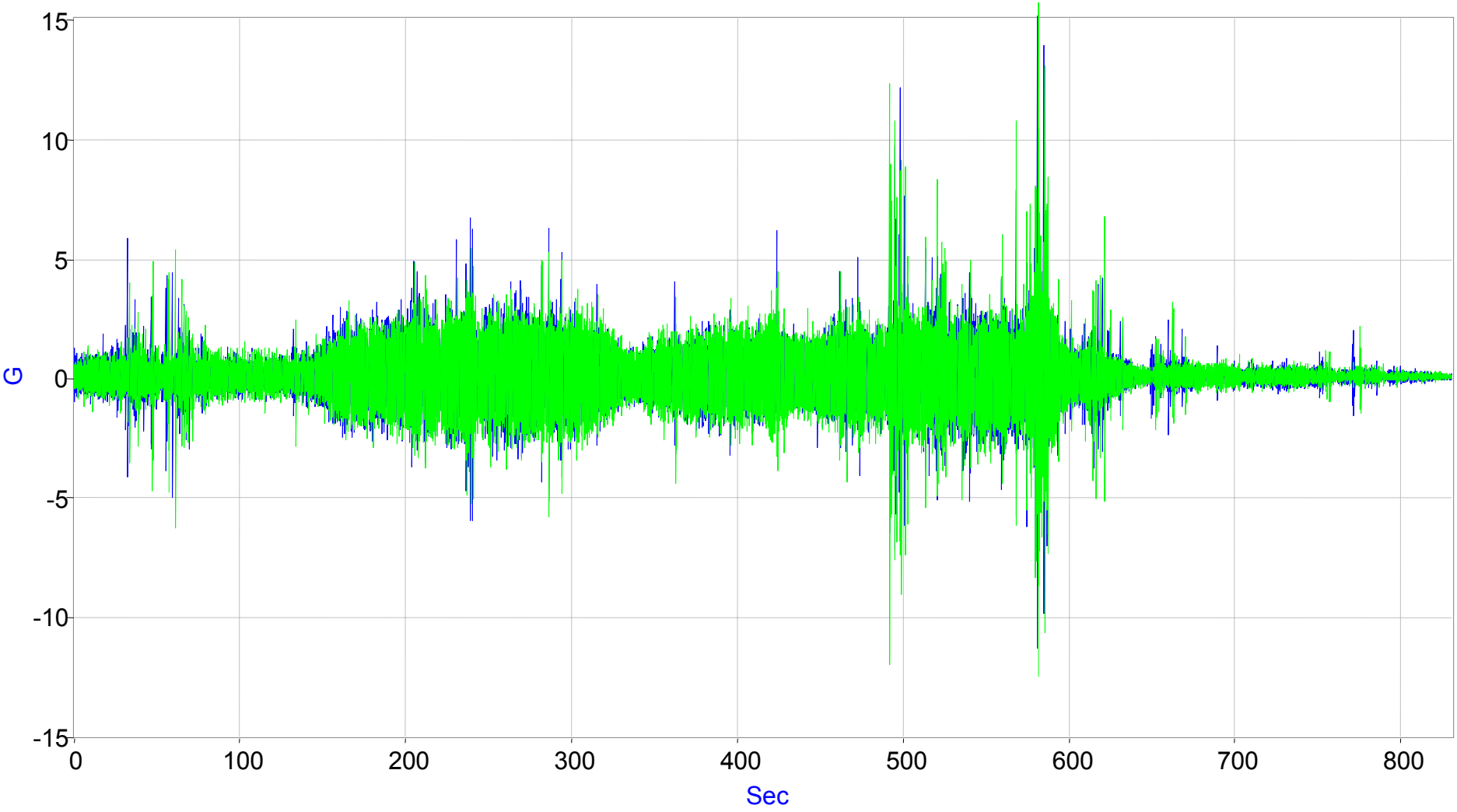
6/18/2005 – File 24

Truck Lateral Accel, blue = WABTEC/SAB-WABCO, green = Knorr



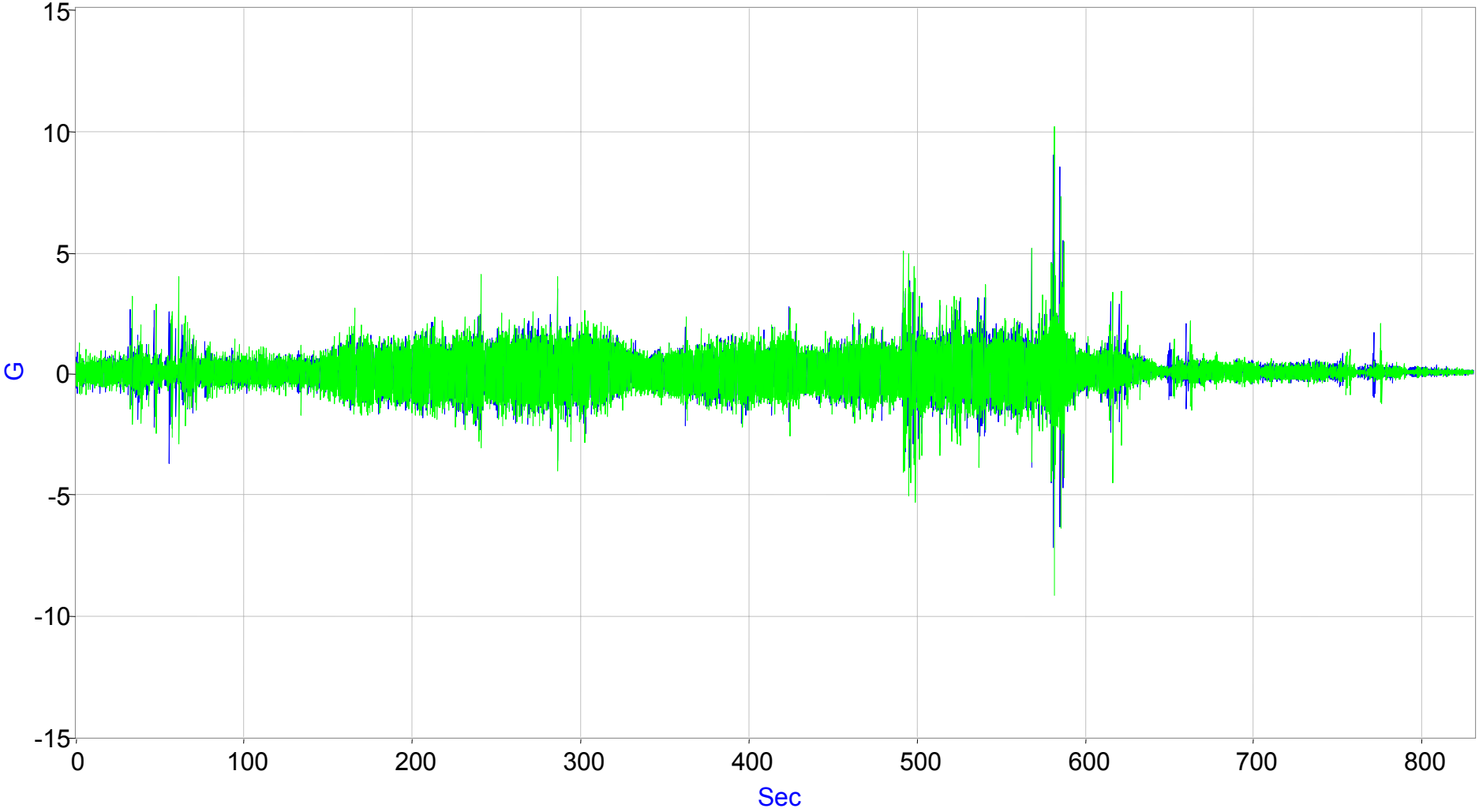
6/18/2005 – File 24

Truck Vertical Accel, blue = WABTEC/SAB-WABCO, green = Knorr

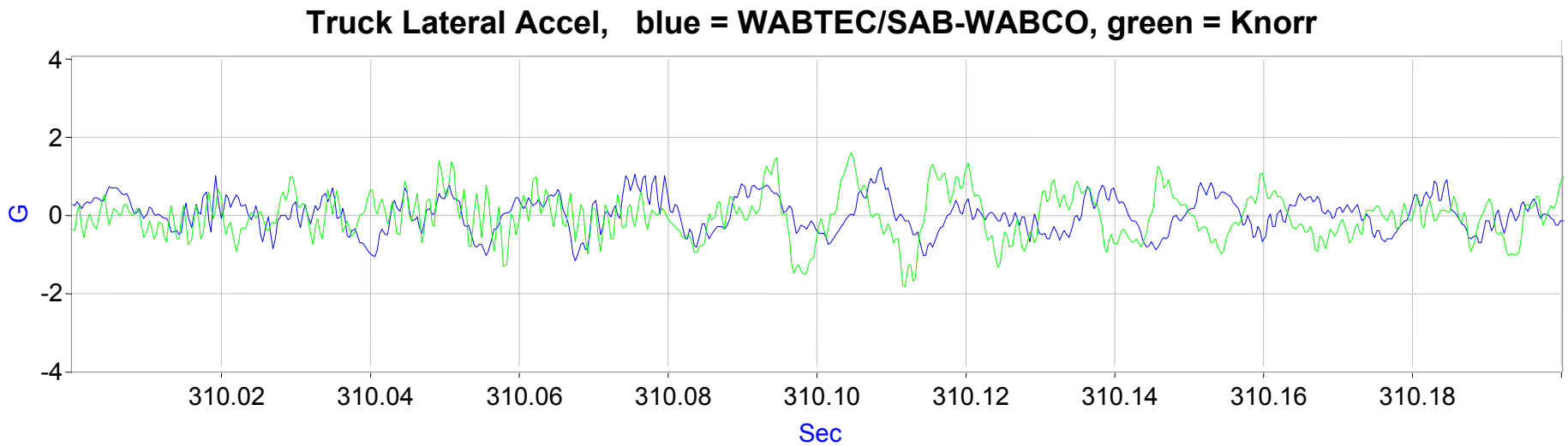


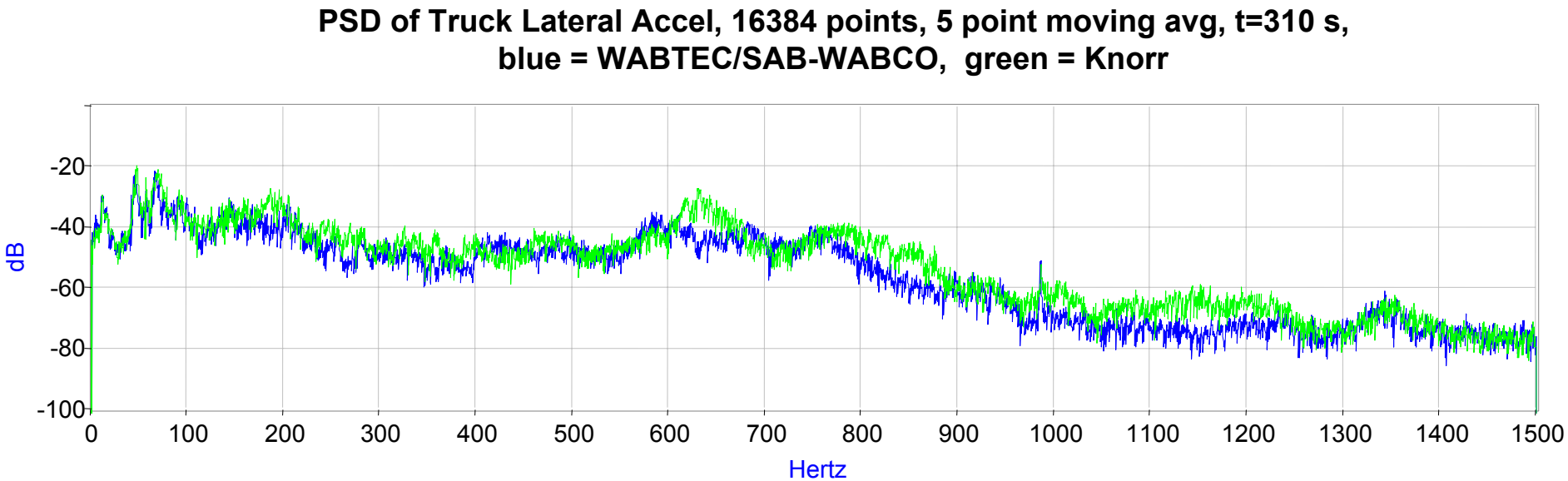
6/18/2005 – File 24

Truck Longitudinal Accel, blue = WABTEC/SAB-WABCO, green = Knorr

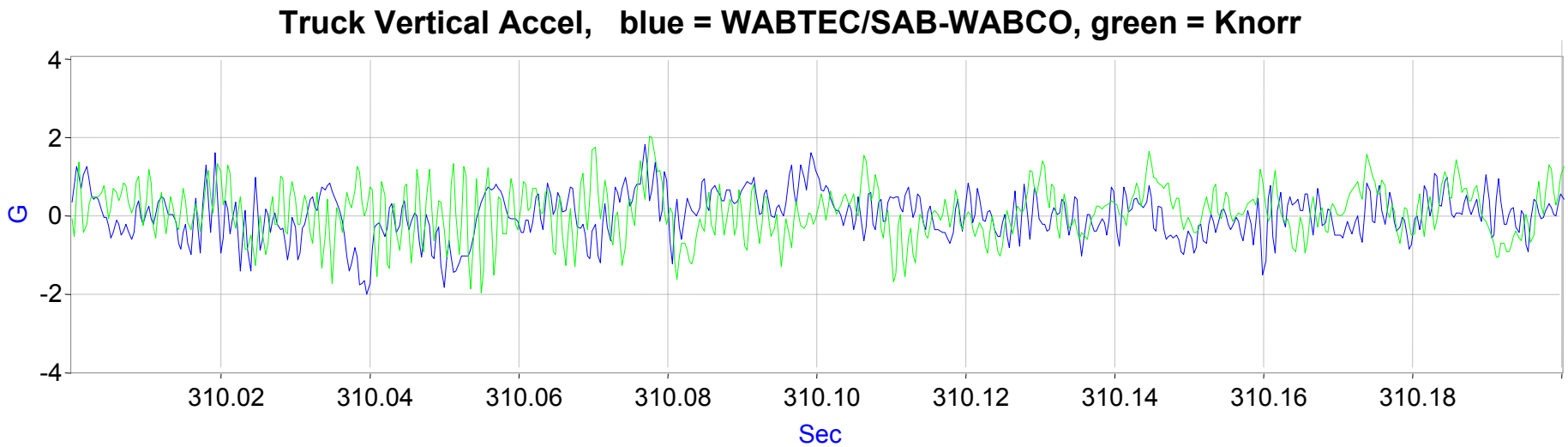


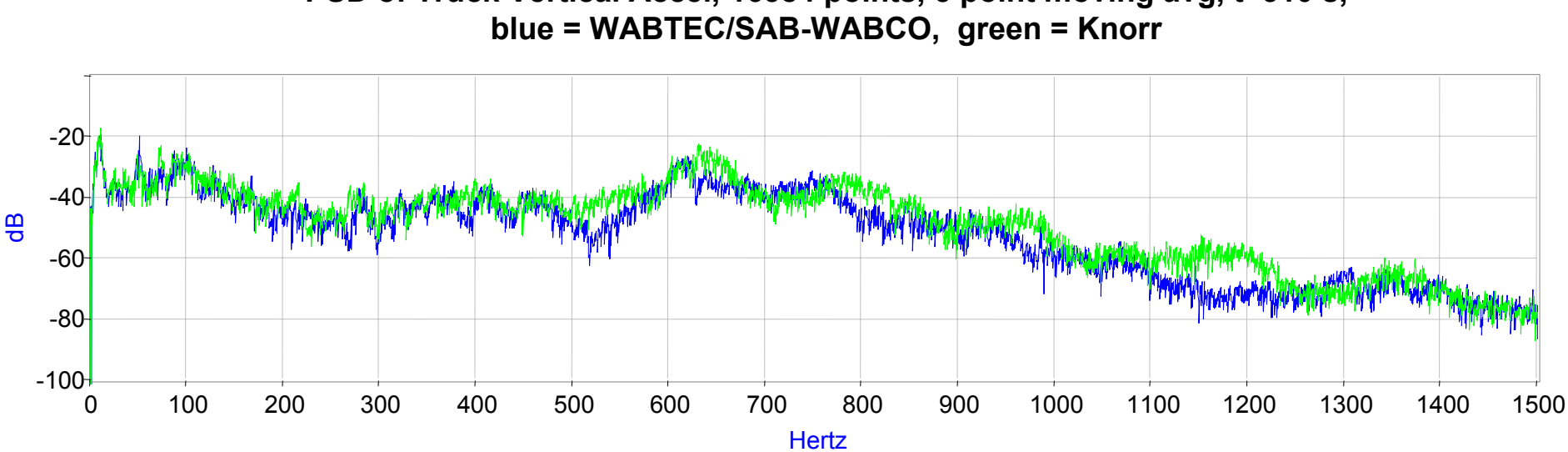
6/18/2005 – File 24 (brake, no SO)



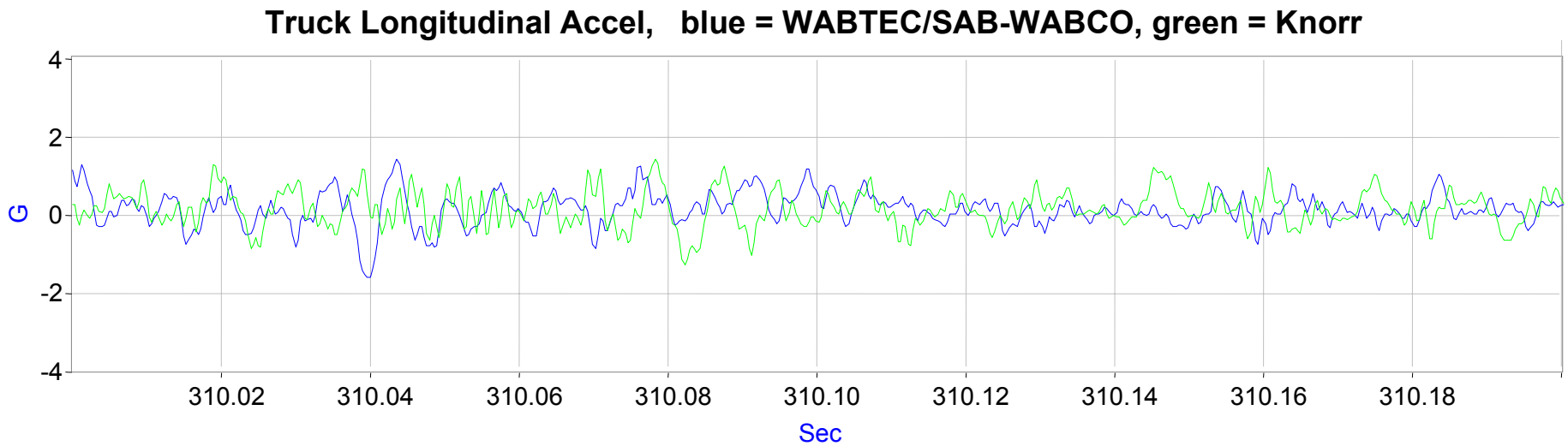


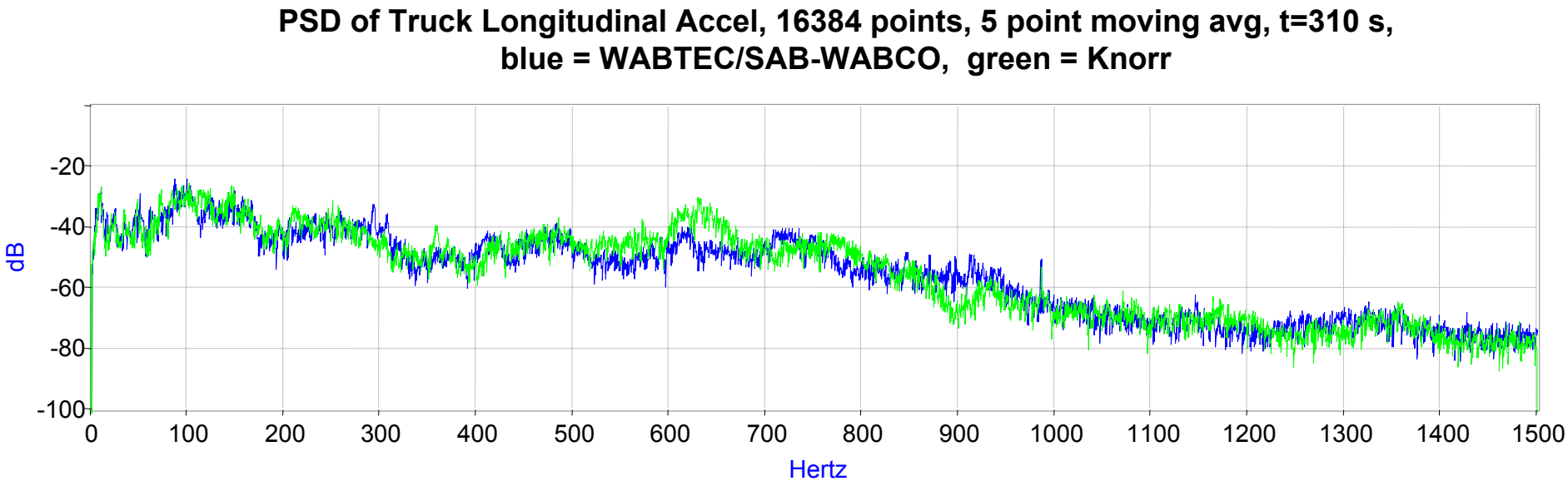
6/18/2005 – File 24 (brake, no SO)





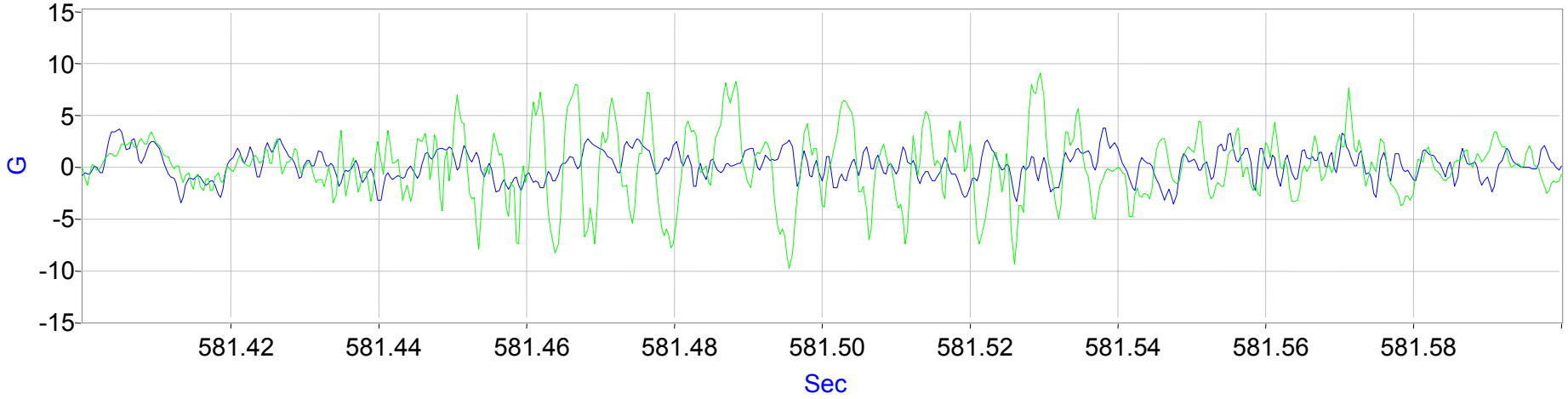
6/18/2005 – File 24 (brake, no SO)



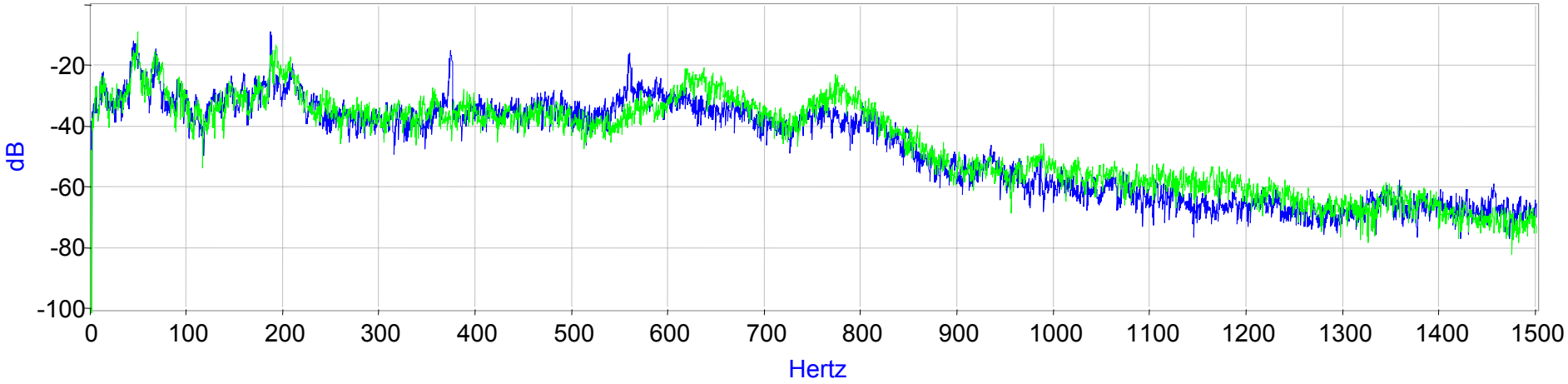


6/18/2005 – File 24 (brake, SO)

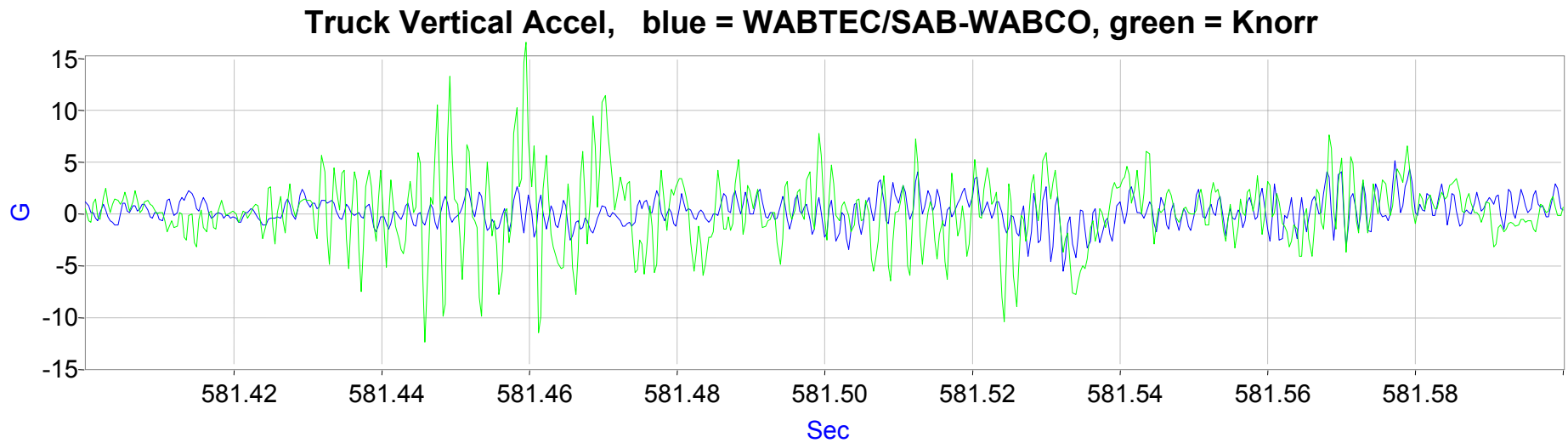
Truck Lateral Accel, blue = WABTEC/SAB-WABCO, green = Knorr

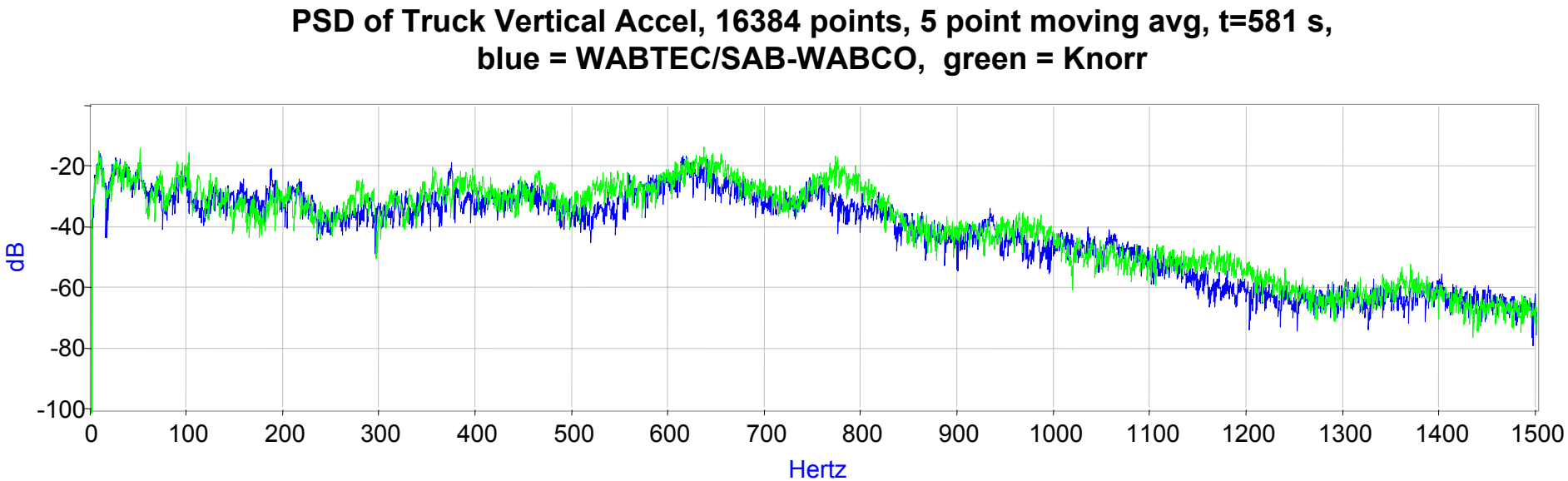


PSD of Truck Lateral Accel, 16384 points, 5 point moving avg, t=581 s, blue = WABTEC/SAB-WABCO, green = Knorr

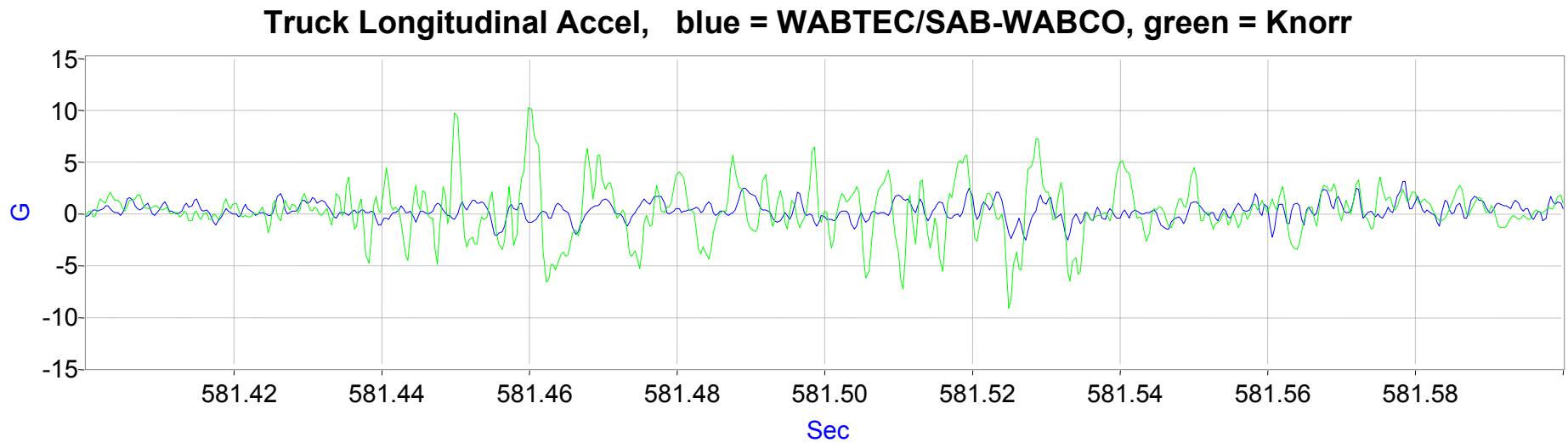


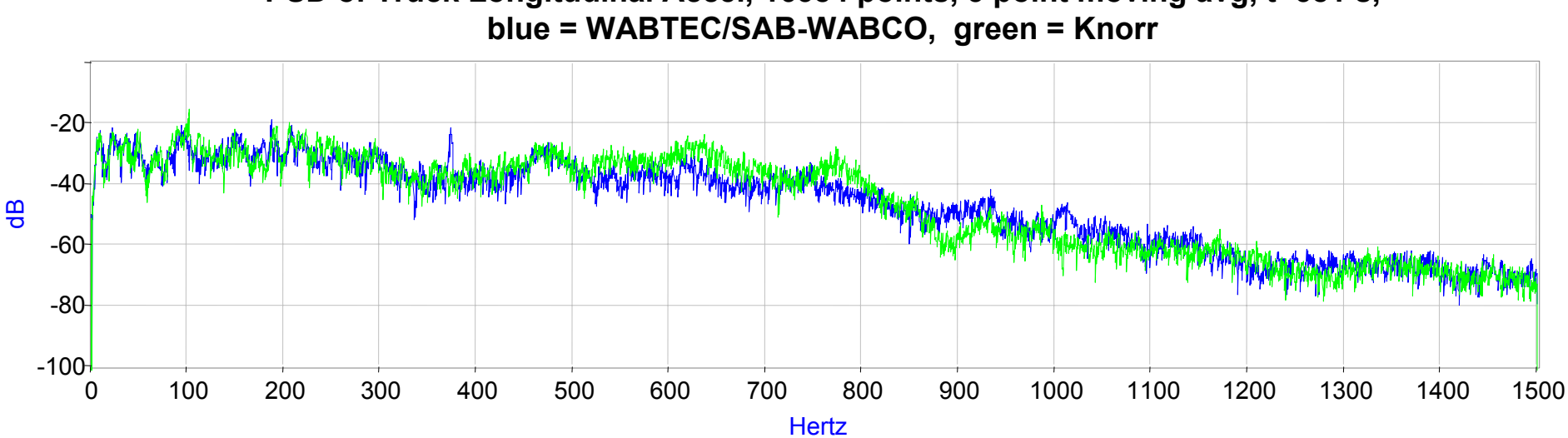
6/18/2005 – File 24 (brake, SO)



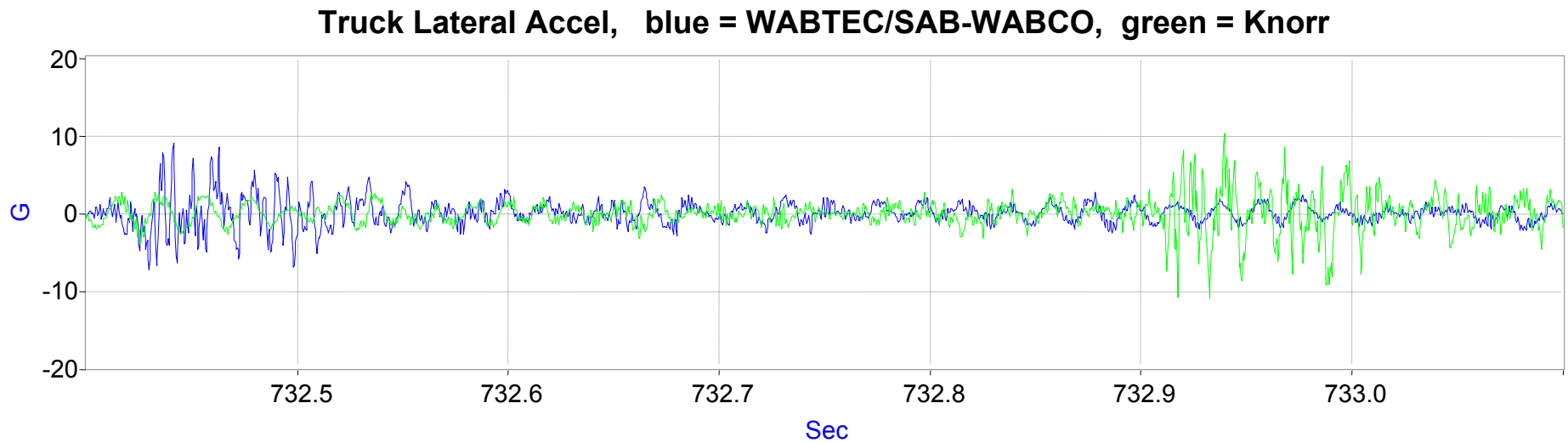


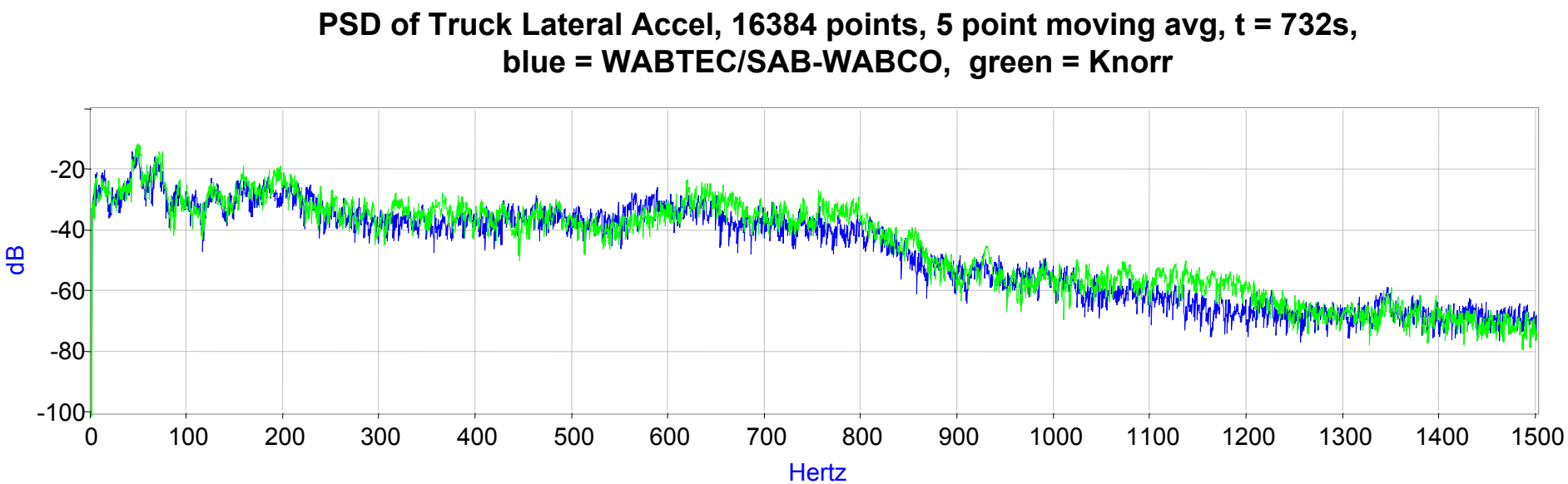
6/18/2005 – File 24 (brake, SO)



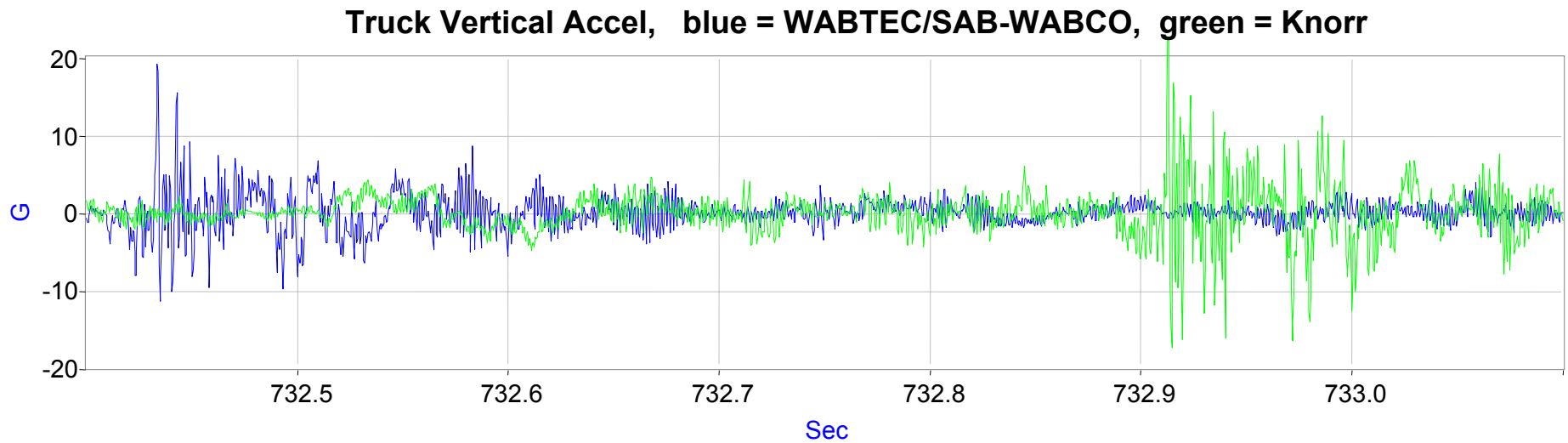


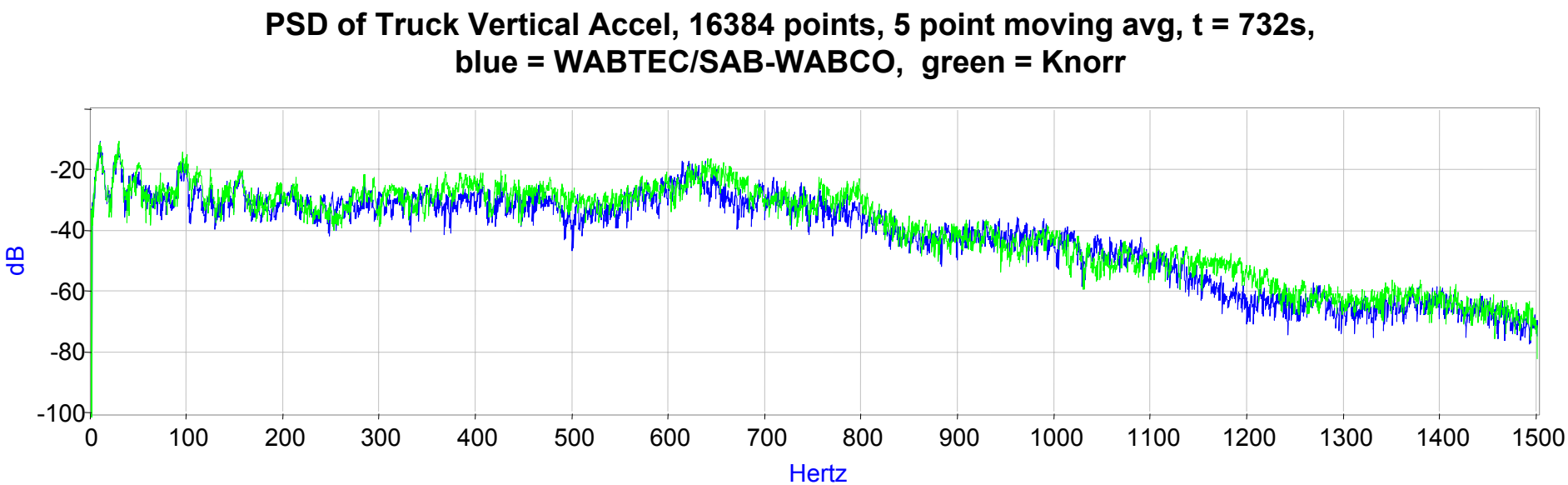
6/18/2005 – File 30 (no brake)





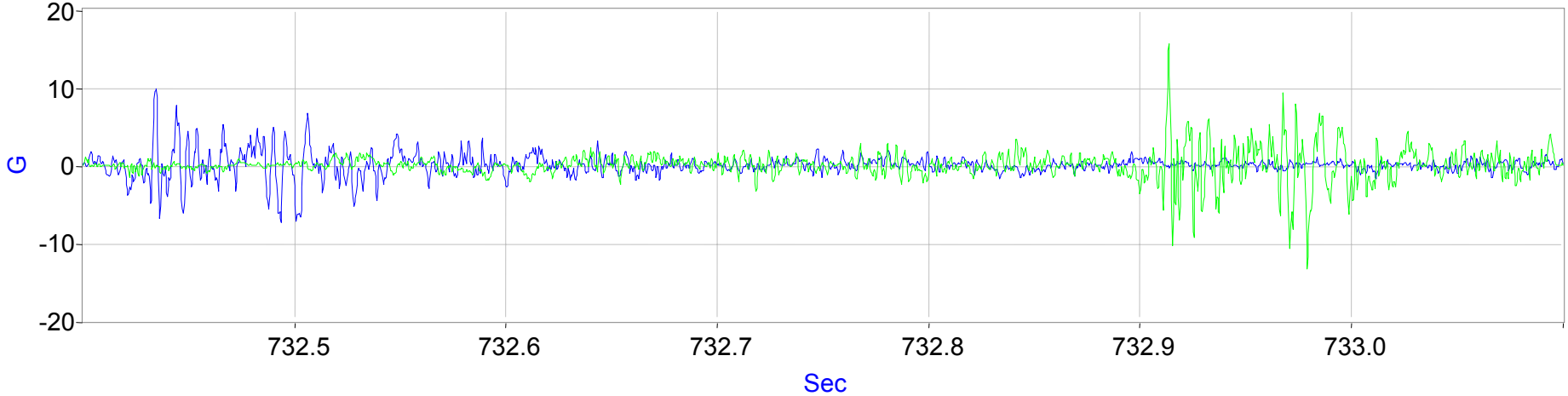
6/18/2005 – File 30 (no brake)



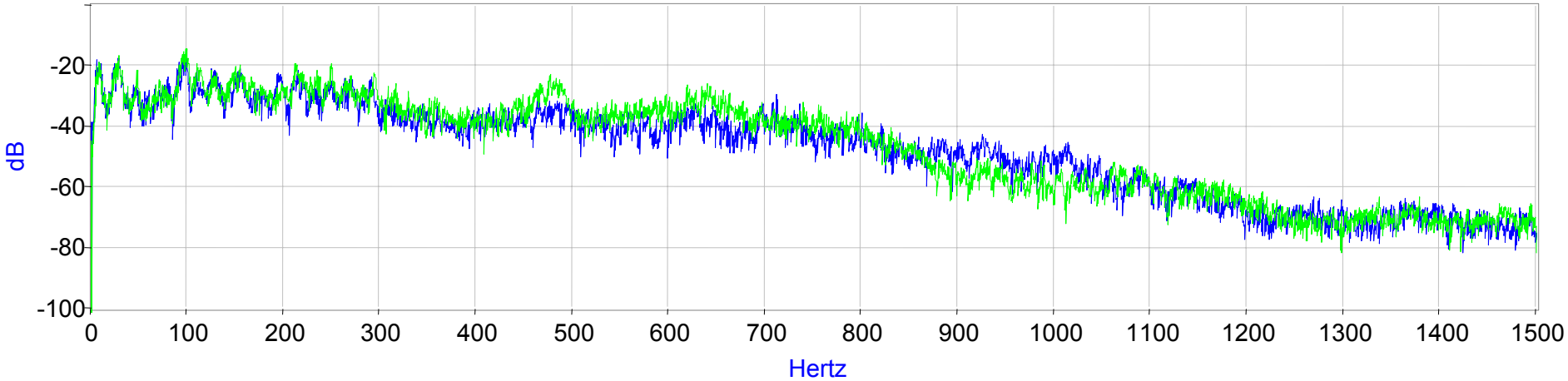


6/18/2005 – File 30 (no brake)

Truck Longitudinal Accel, blue = WABTEC/SAB-WABCO, green = Knorr



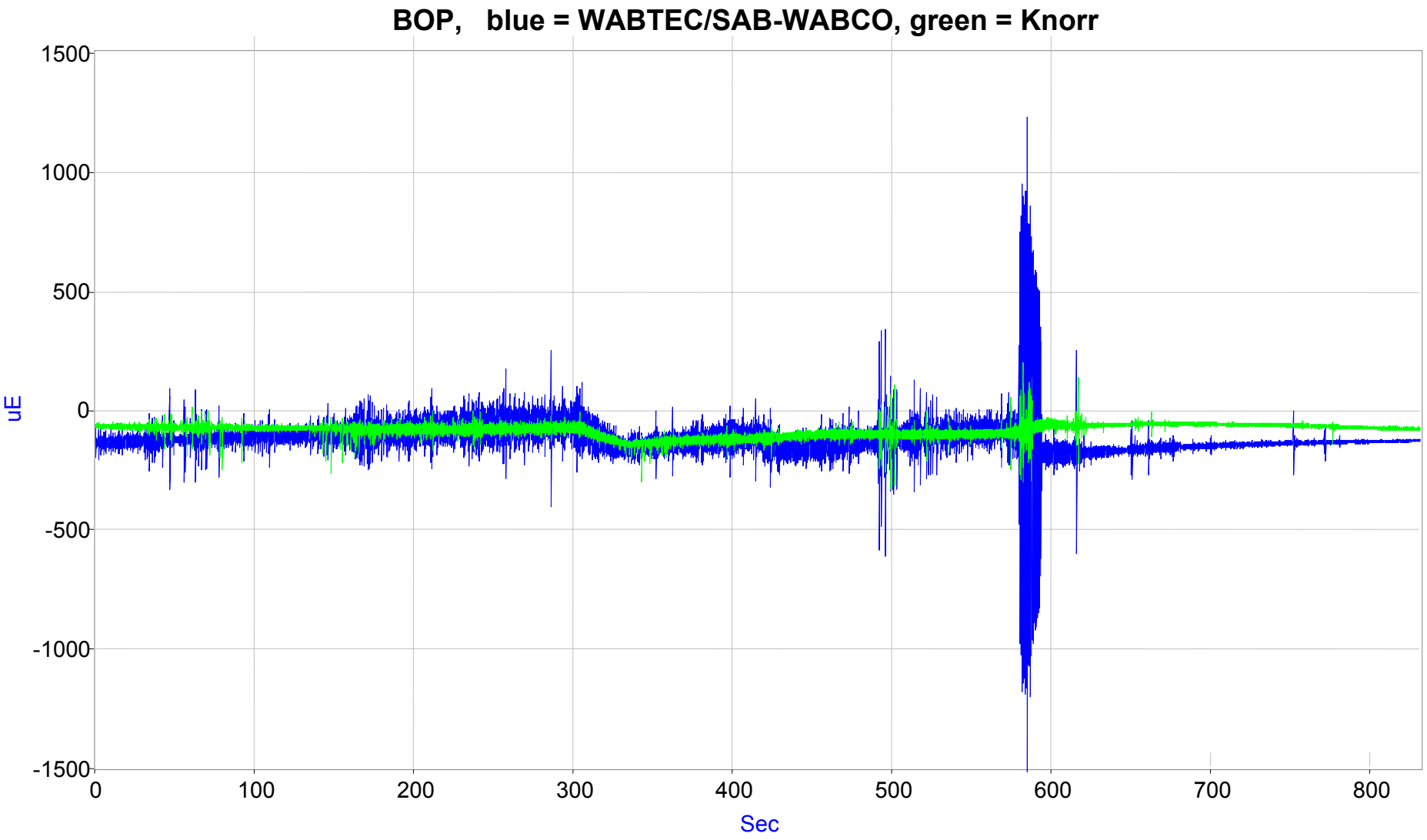
PSD of Truck Longitudinal Accel, 16384 points, 5 point moving avg, t = 732s, blue = WABTEC/SAB-WABCO, green = Knorr



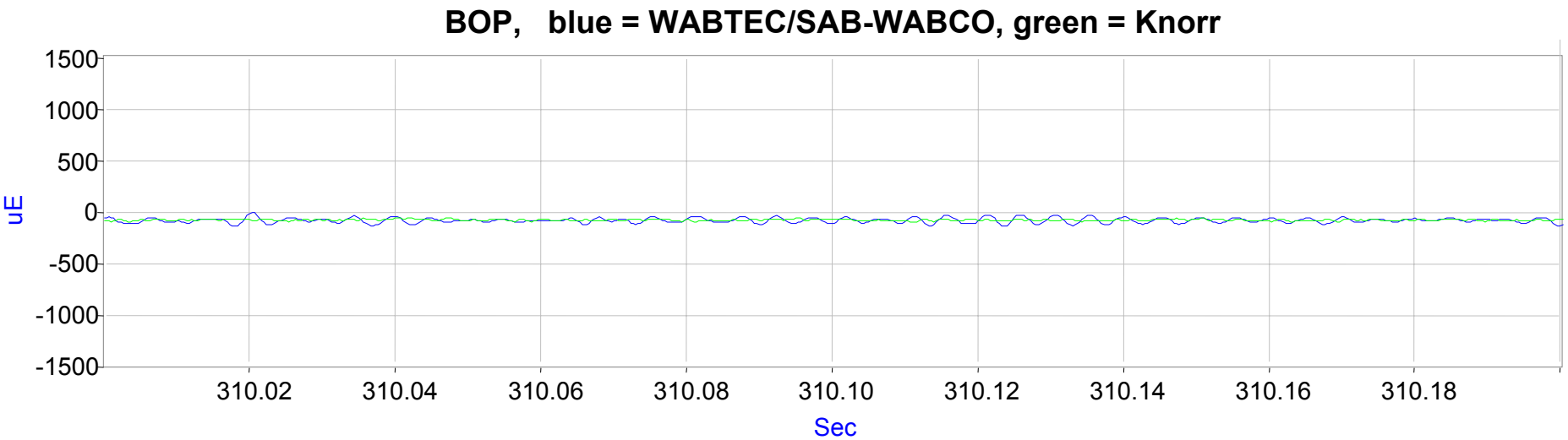
BOP Responses

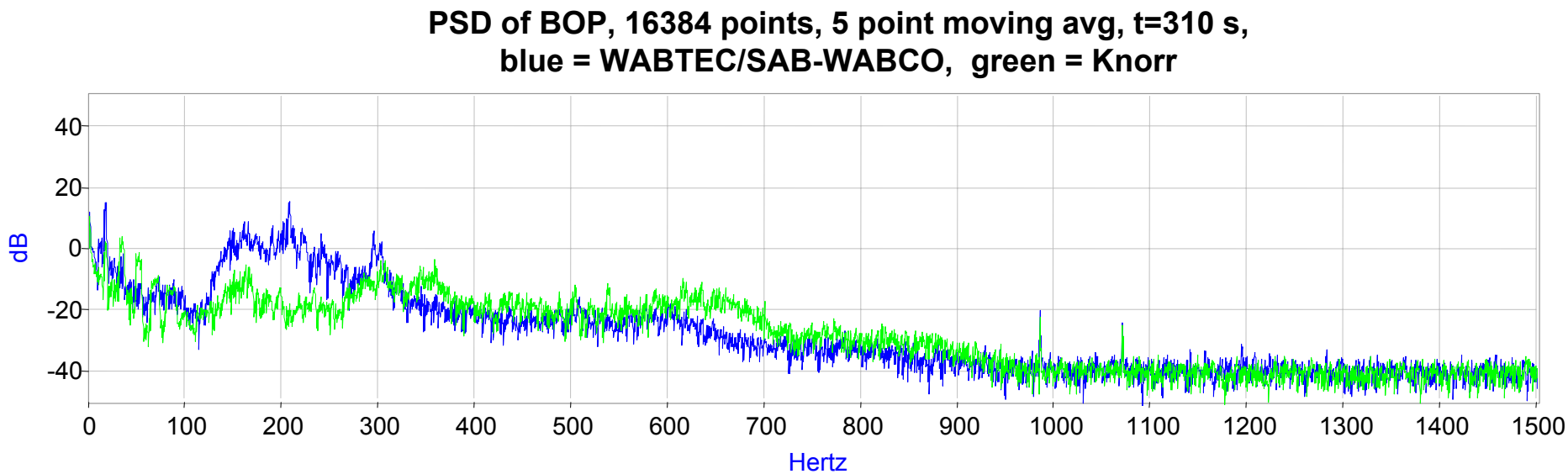
- June 18, 2005 File 24, t = 310 - No BOP, Braking
- June 18, 2005 File 24, t = 581 - BOP, Braking
- June 18, 2005 File 30, t=732 – BOP, Response to Impact

6/18/2005 – File 24

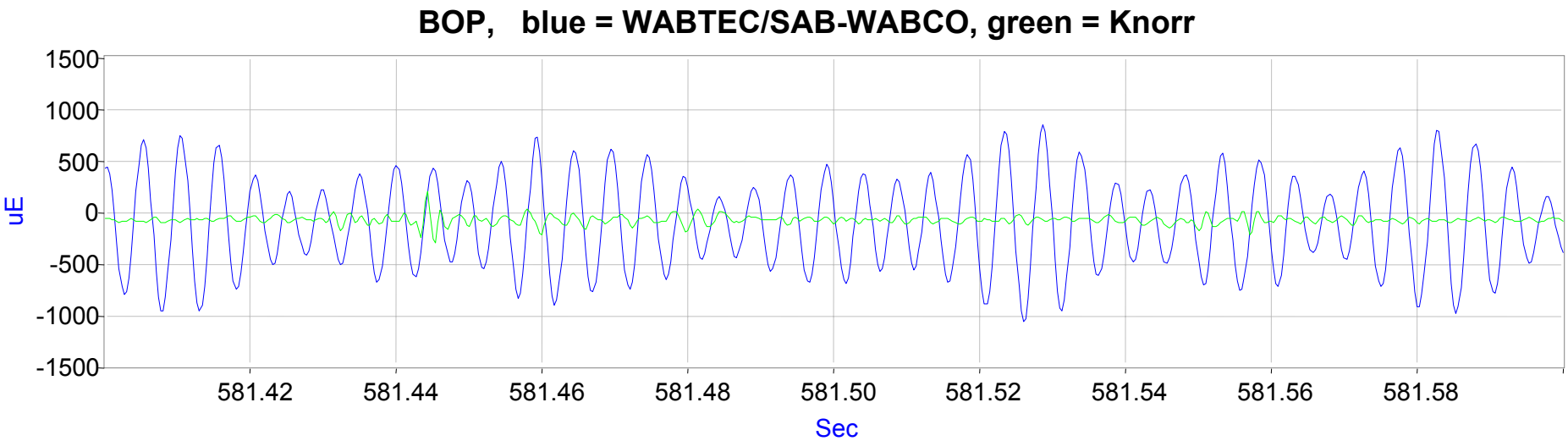


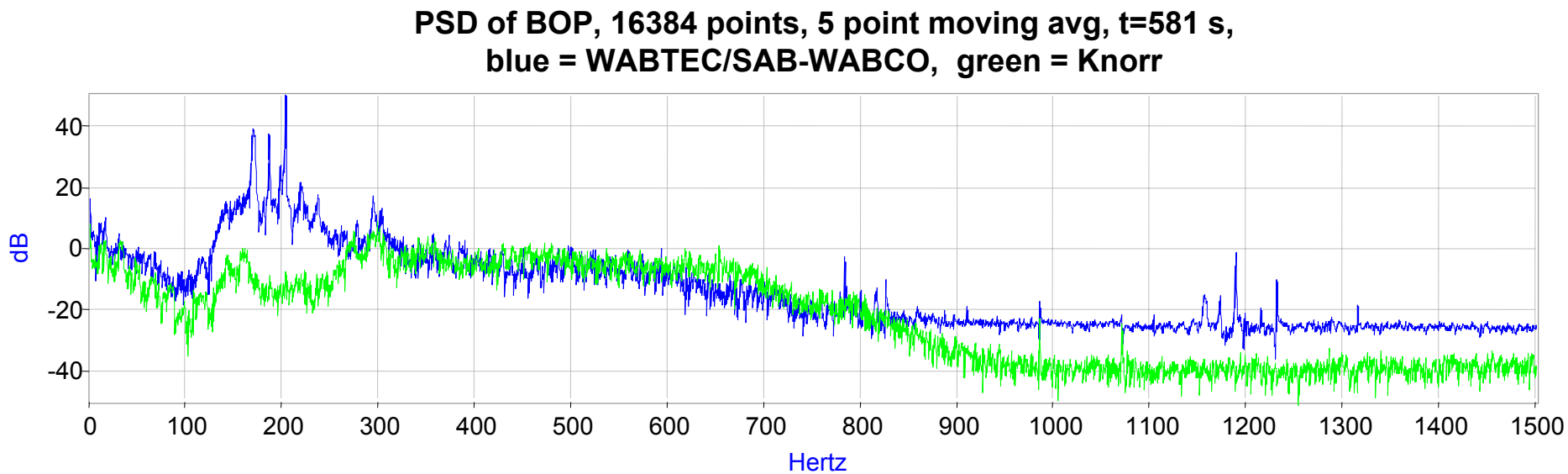
6/18/2005 – File 24 (brake, no SO)



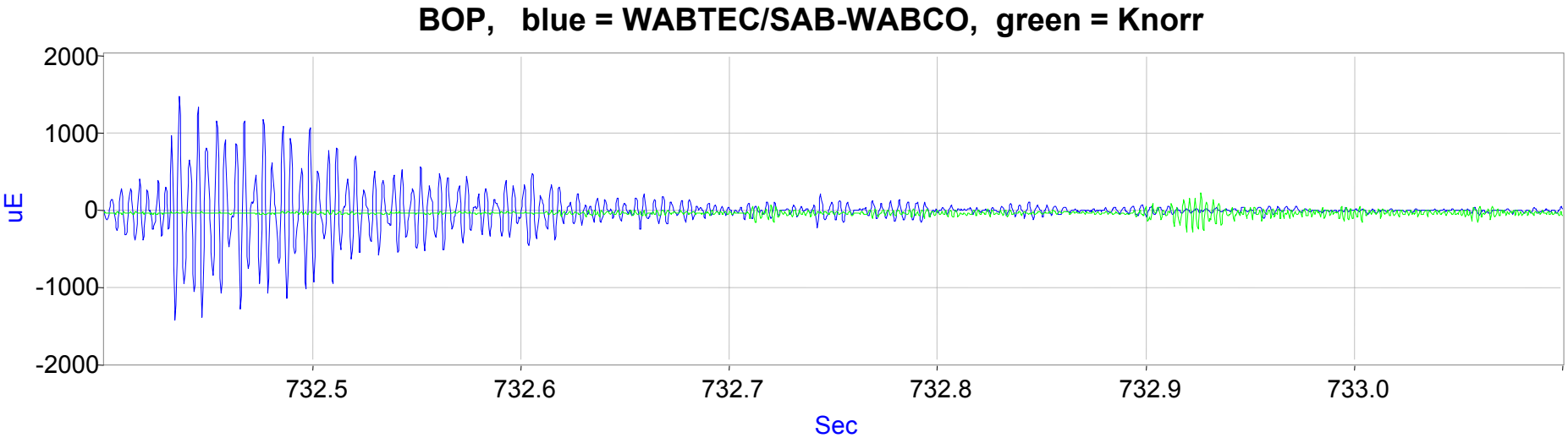


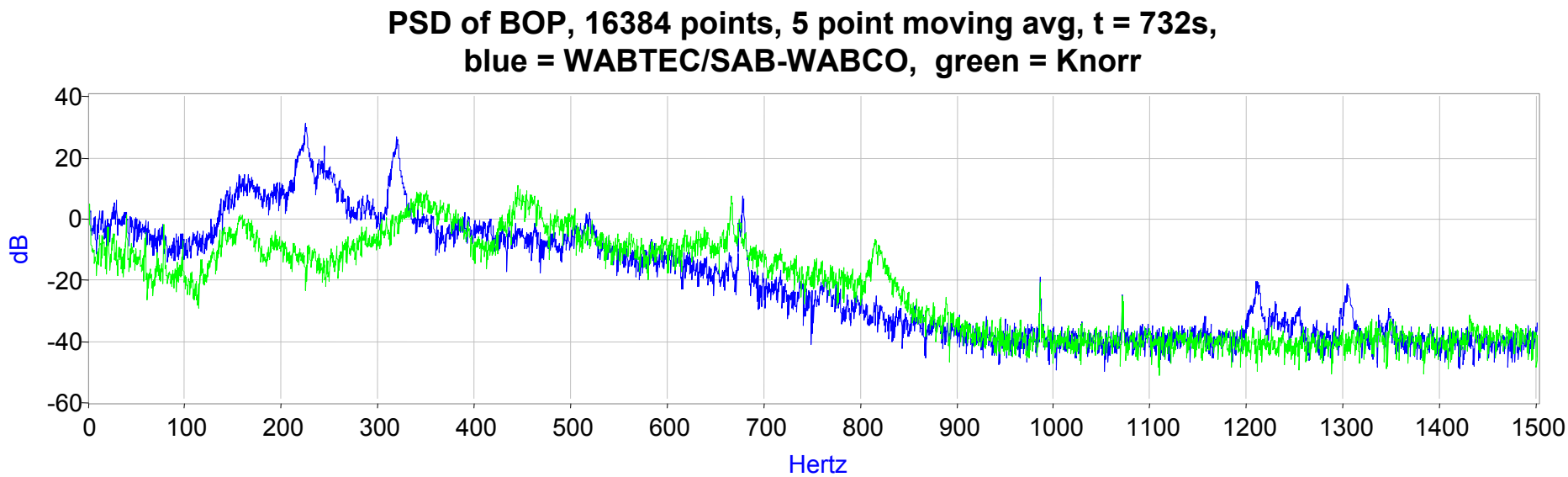
6/18/2005 – File 24 (brake, SO)





6/18/2005 – File 30 (no brake)

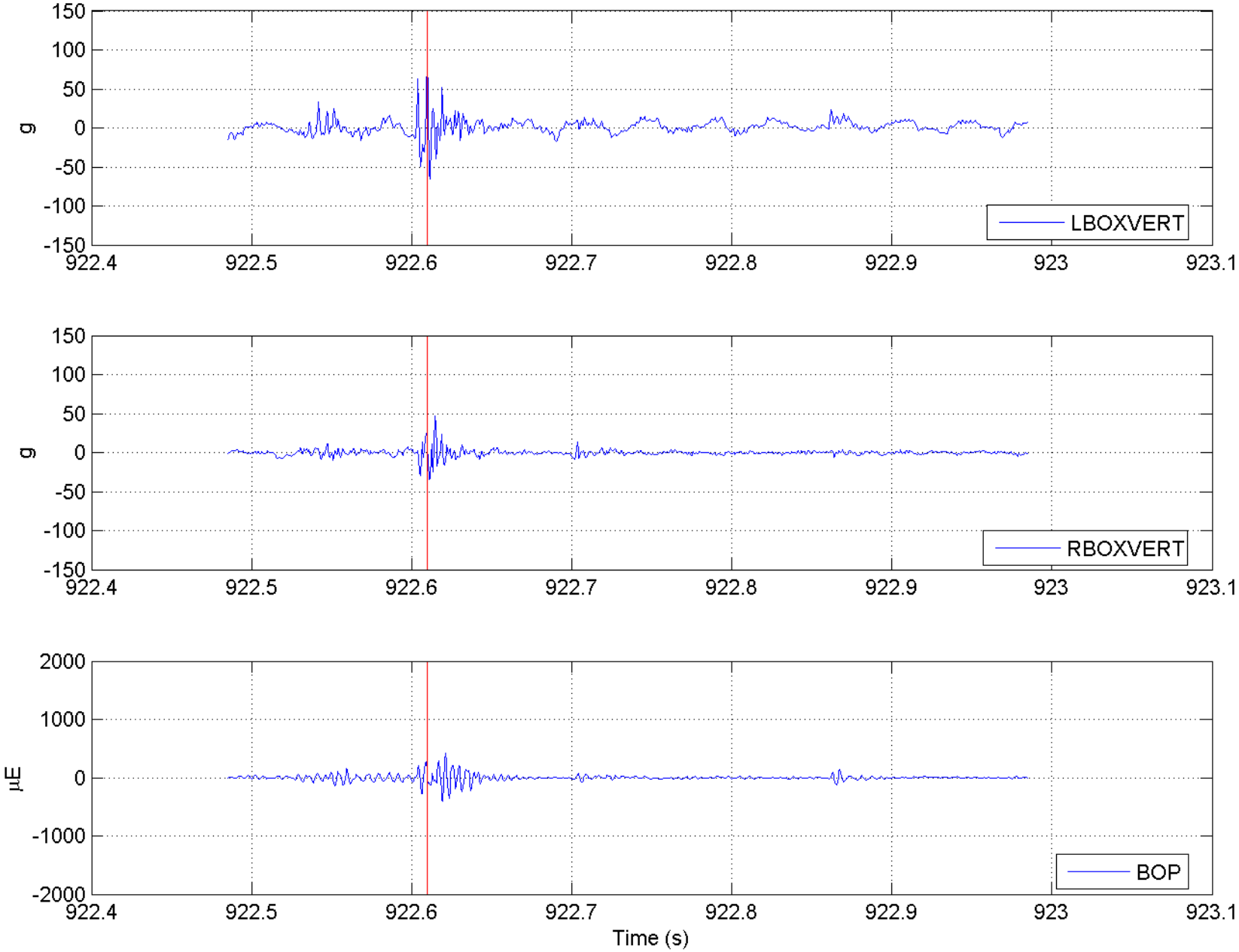




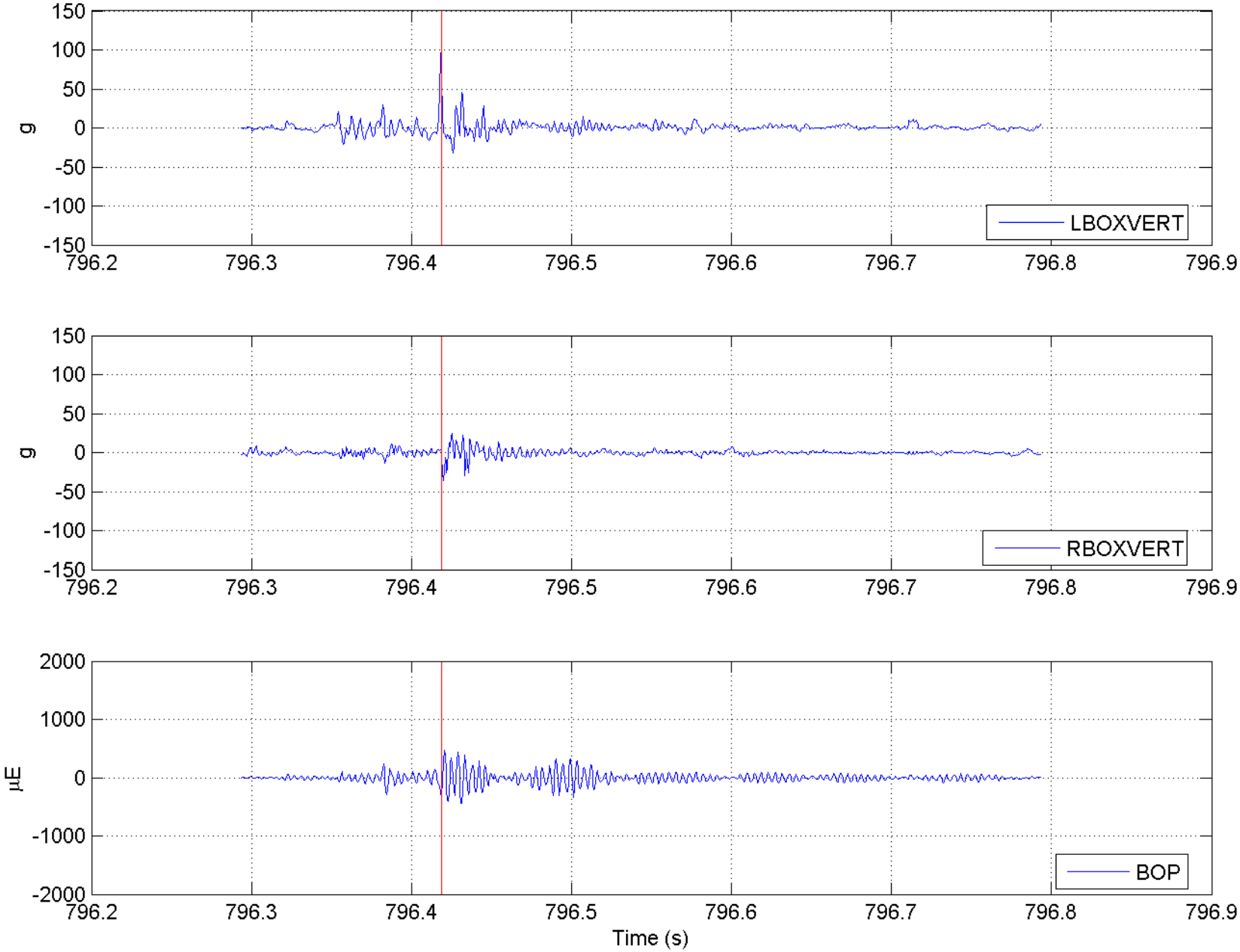
Plots of Axle Vertical Accelerations Exceeding 100 G

Day 1 – May 16, 2005

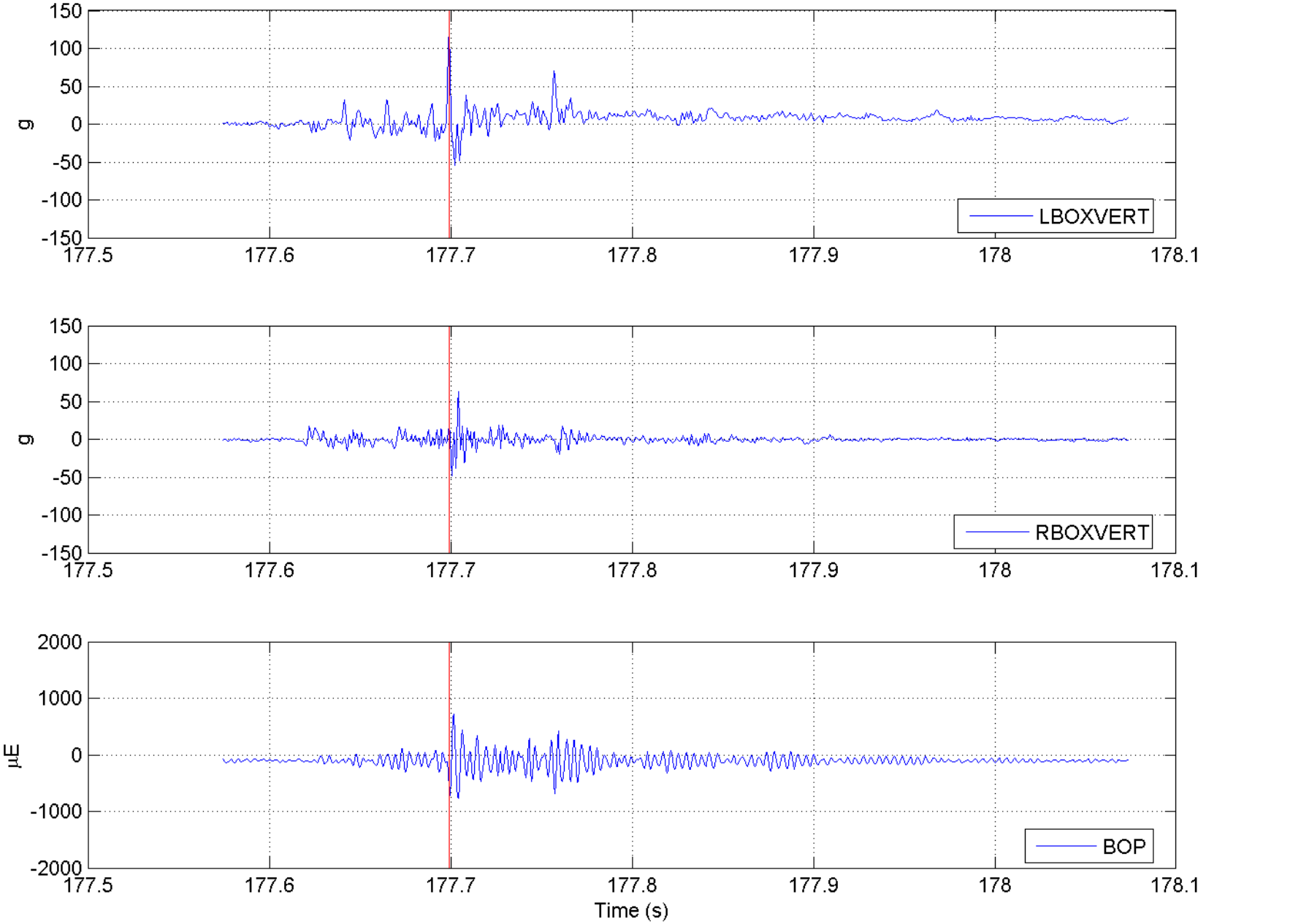
File 051605_08.ABT, Location 922.61 s, LBOXVERT = 103.78 g, RBOXVERT = 47.51 g, BOP = 426.5 uE, Speed = 94.6508 mph, Brake Pressure = 11.846



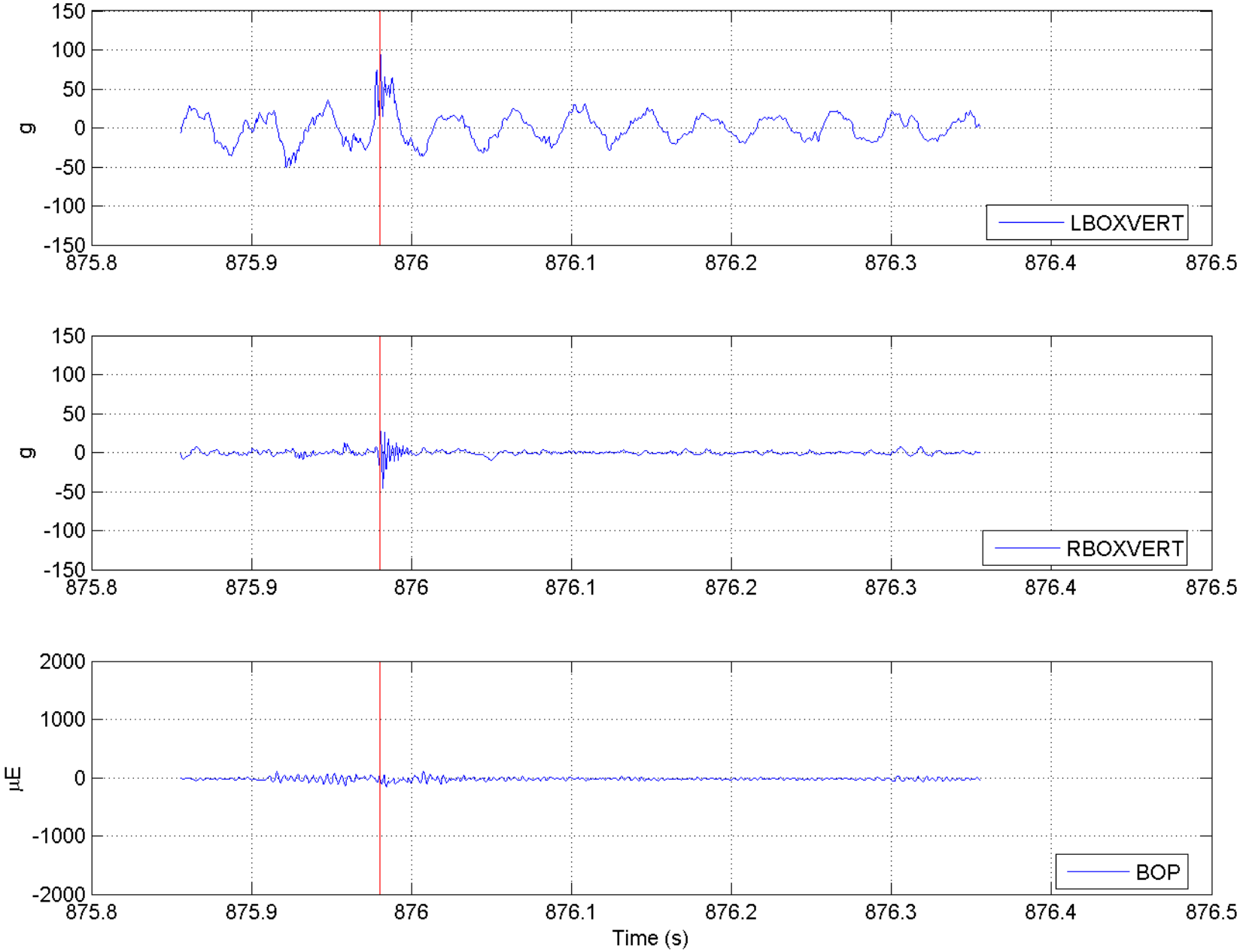
File 051605_09.ABT, Location 796.4185 s, LBOXVERT = 102.23 g, RBOXVERT = 36.28 g, BOP = 468 uE, Speed = 100.5873 mph, Brake Pressure = 0.539



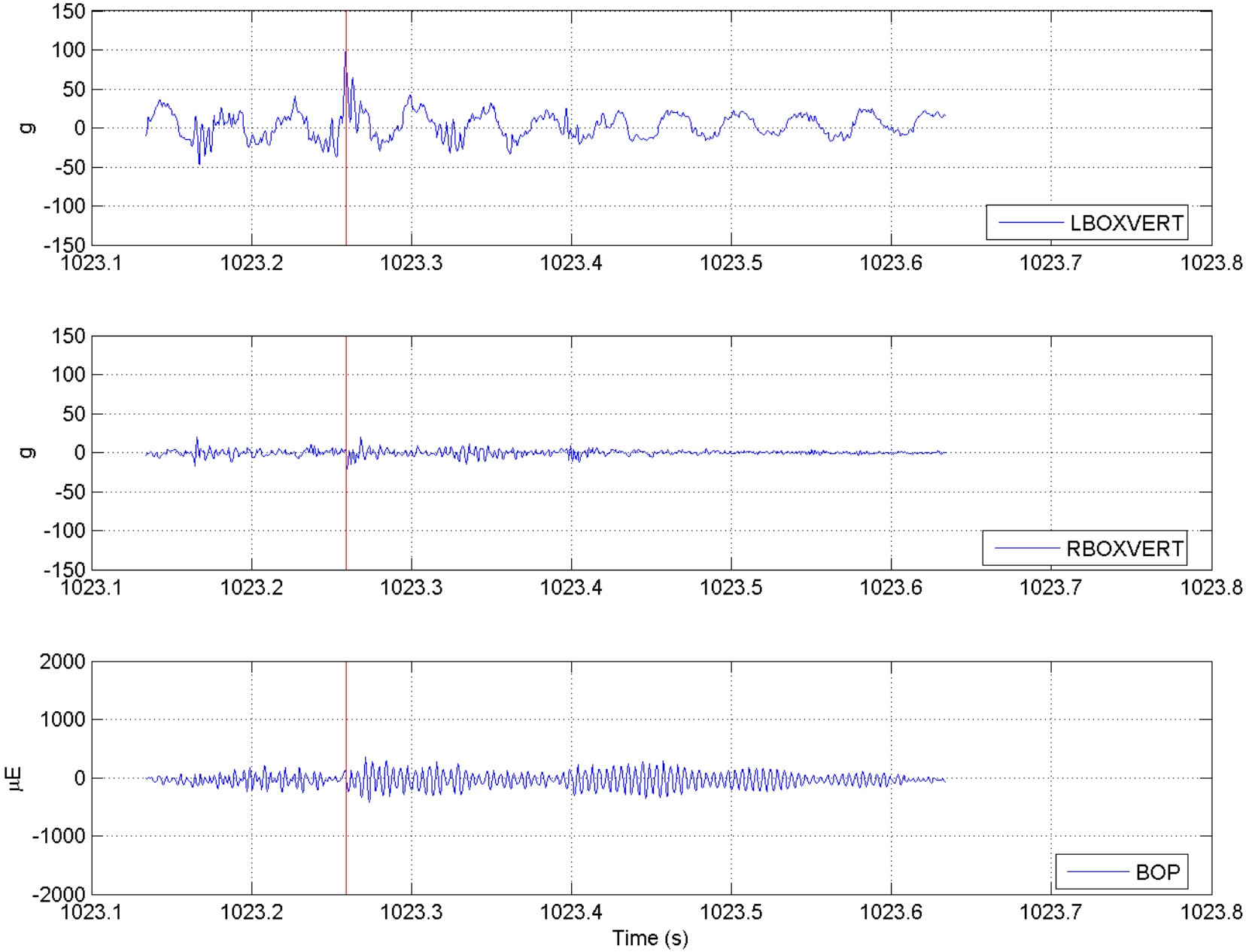
File 051605_10.ABT, Location 177.699 s, LBOXVERT = 126.05 g, RBOXVERT = 62.75 g, BOP = 766 uE, Speed = 110.5908 mph, Brake Pressure = 0.5458



File 051605_10.ABT, Location 875.9805 s, LBOXVERT = 101.87 g, RBOXVERT = 45.21 g, BOP = 149 uE, Speed = 124.2839 mph, Brake Pressure = 1.637

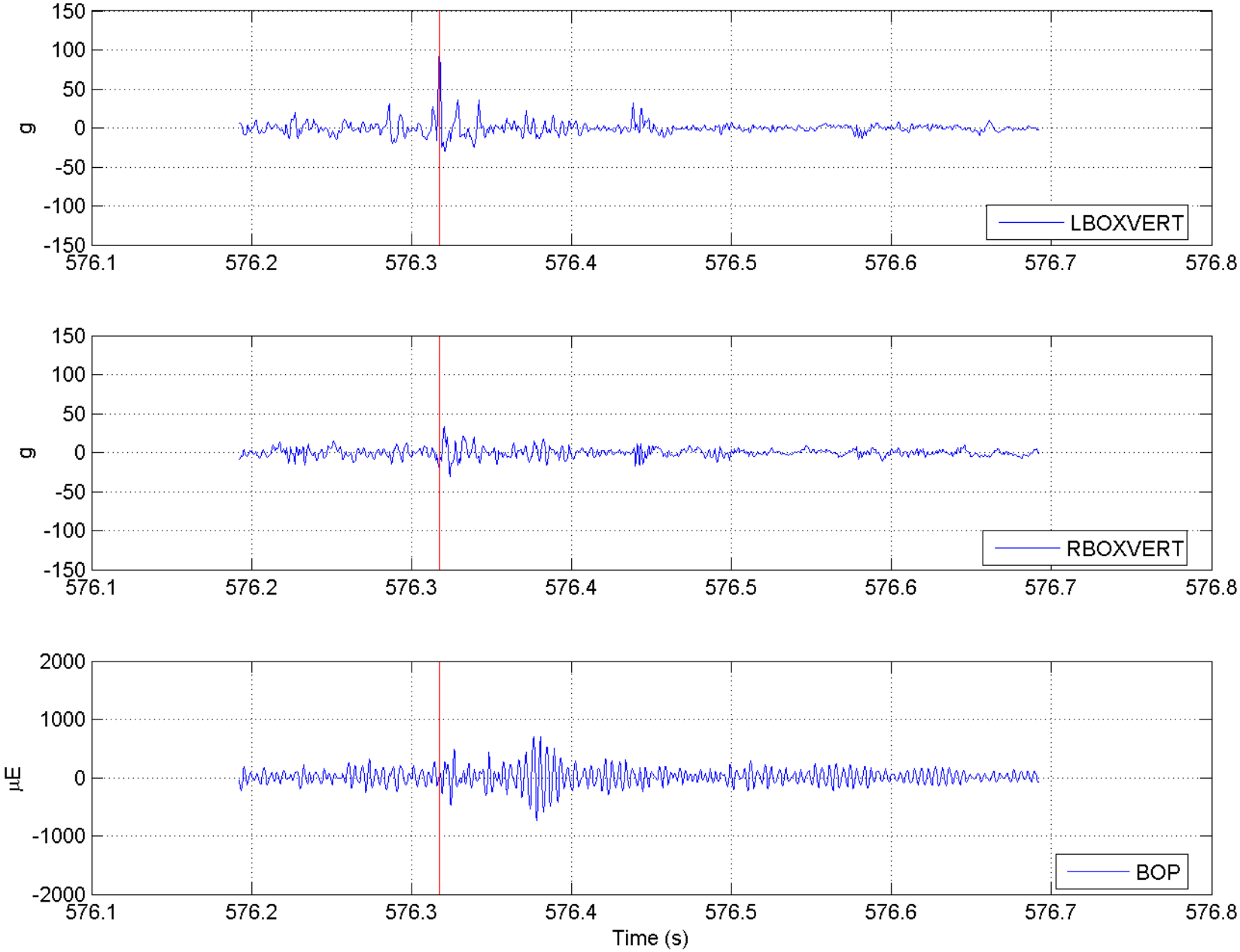


File 051605_10.ABT, Location 1023.259 s, LBOXVERT = 101.04 g, RBOXVERT = 20.45 g, BOP = 416 uE, Speed = 100.4207 mph, Brake Pressure = 1.637

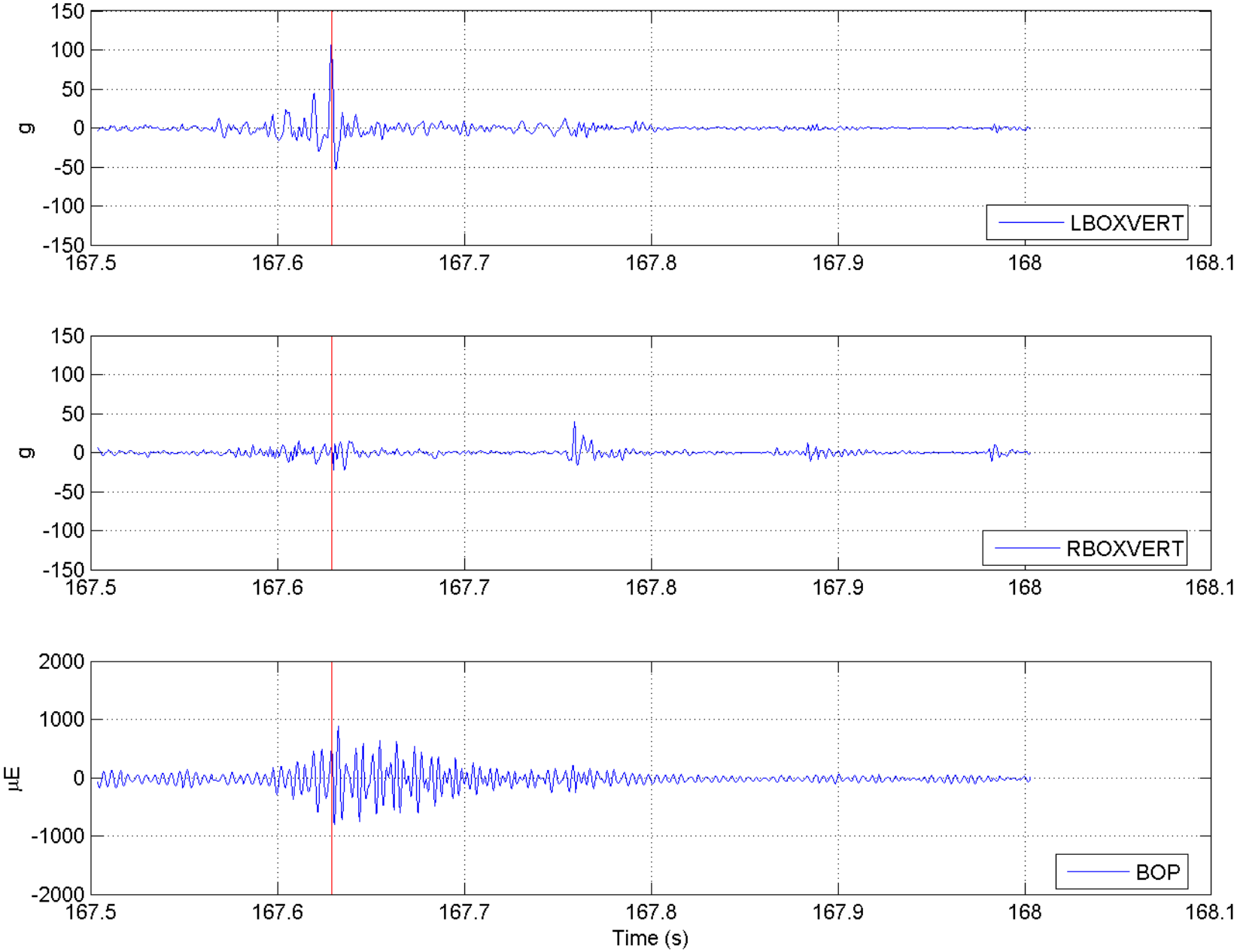


Day 2 – May 17, 2005

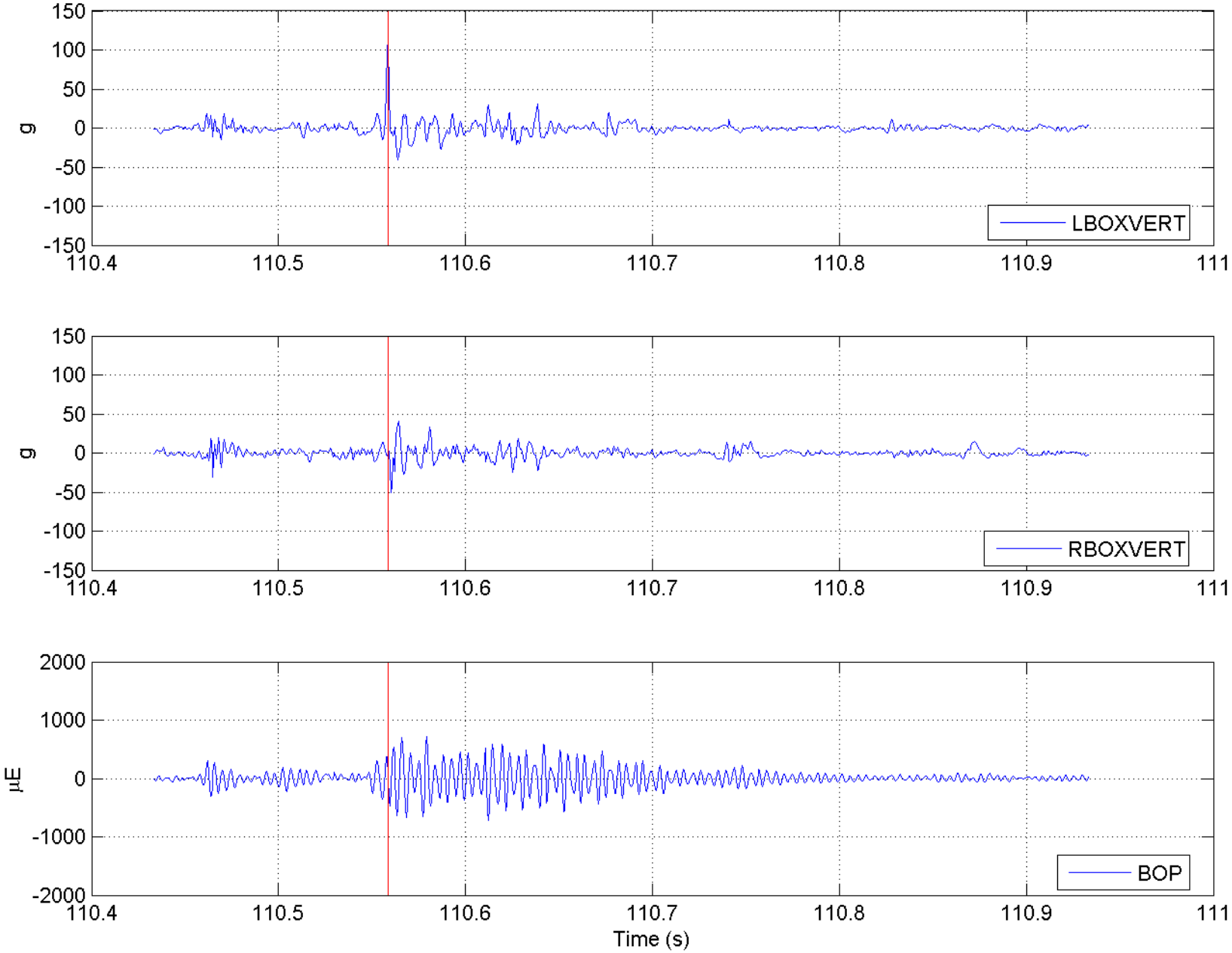
ile 051705_02.ABT, Location 576.3175 s, LBOXVERT = 103.36 g, RBOXVERT = 33.36 g, BOP = 733.5 uE, Speed = 119.4627 mph, Brake Pressure = 0.59



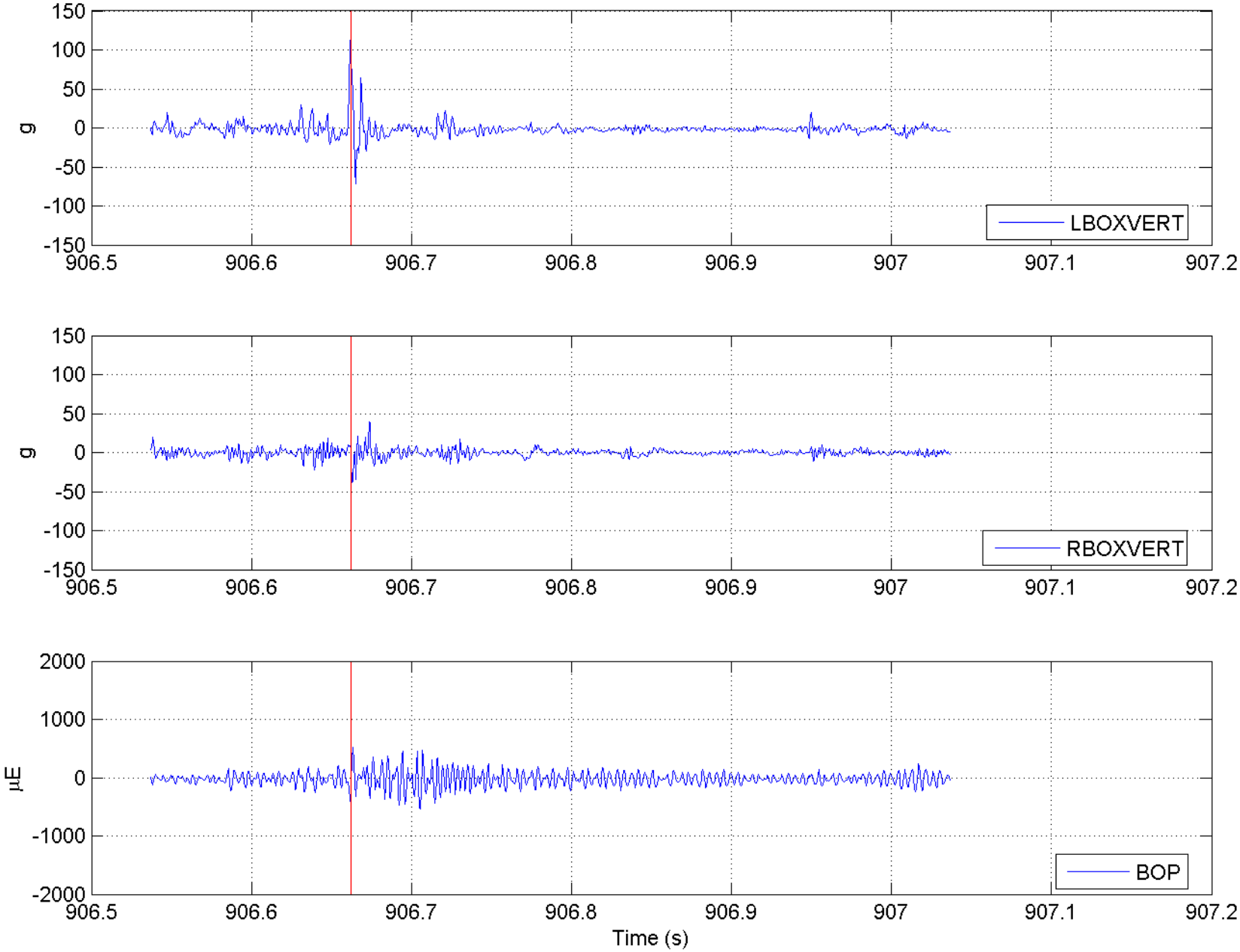
File 051705_14.ABT, Location 167.6285 s, LBOXVERT = 106.9 g, RBOXVERT = 40.05 g, BOP = 883 uE, Speed = 54.5815 mph, Brake Pressure = 0.8533



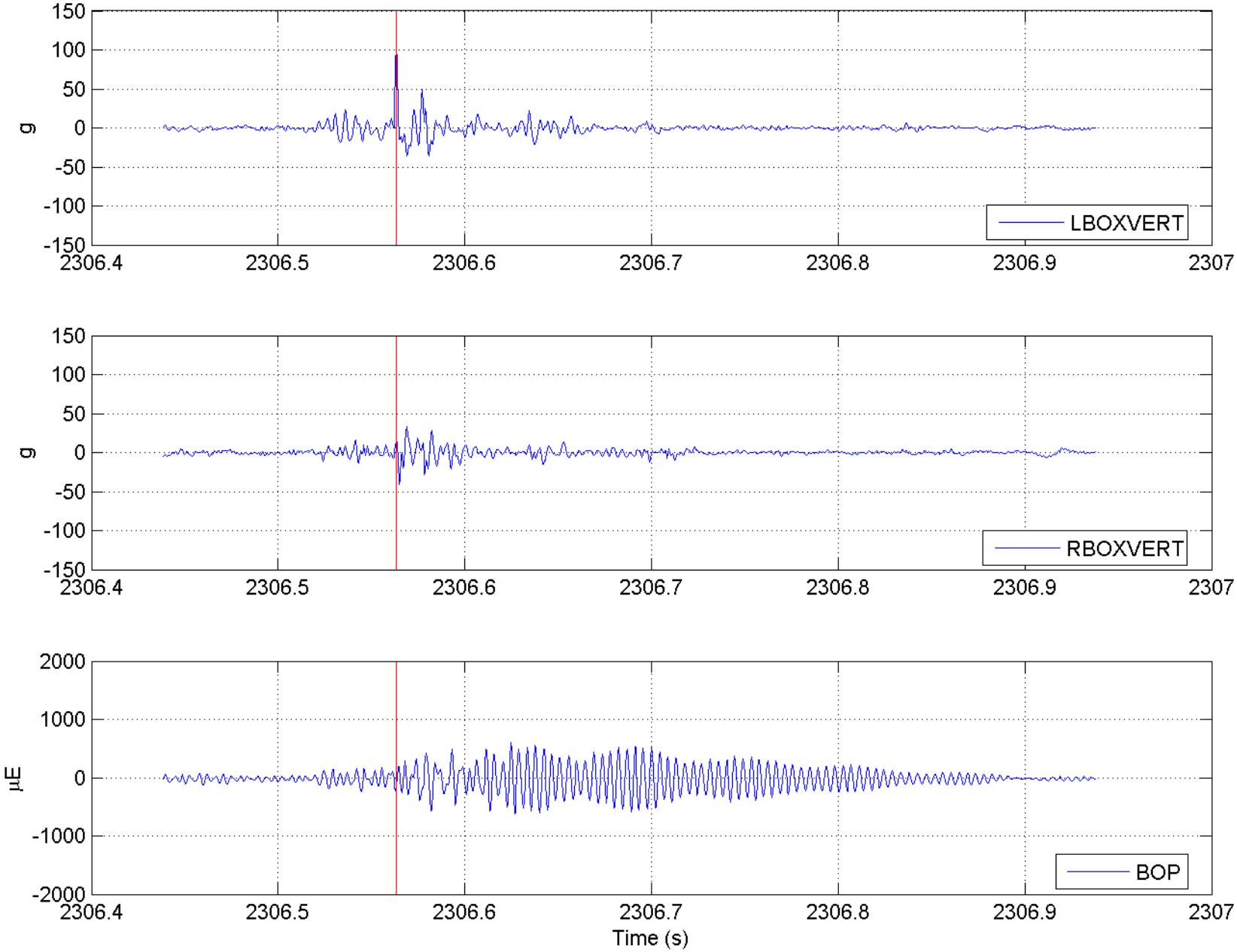
ile 051705_19.ABT, Location 110.5585 s, LBOXVERT = 109.96 g, RBOXVERT = 50.09 g, BOP = 719.5 uE, Speed = 108.0293 mph, Brake Pressure = 0.88



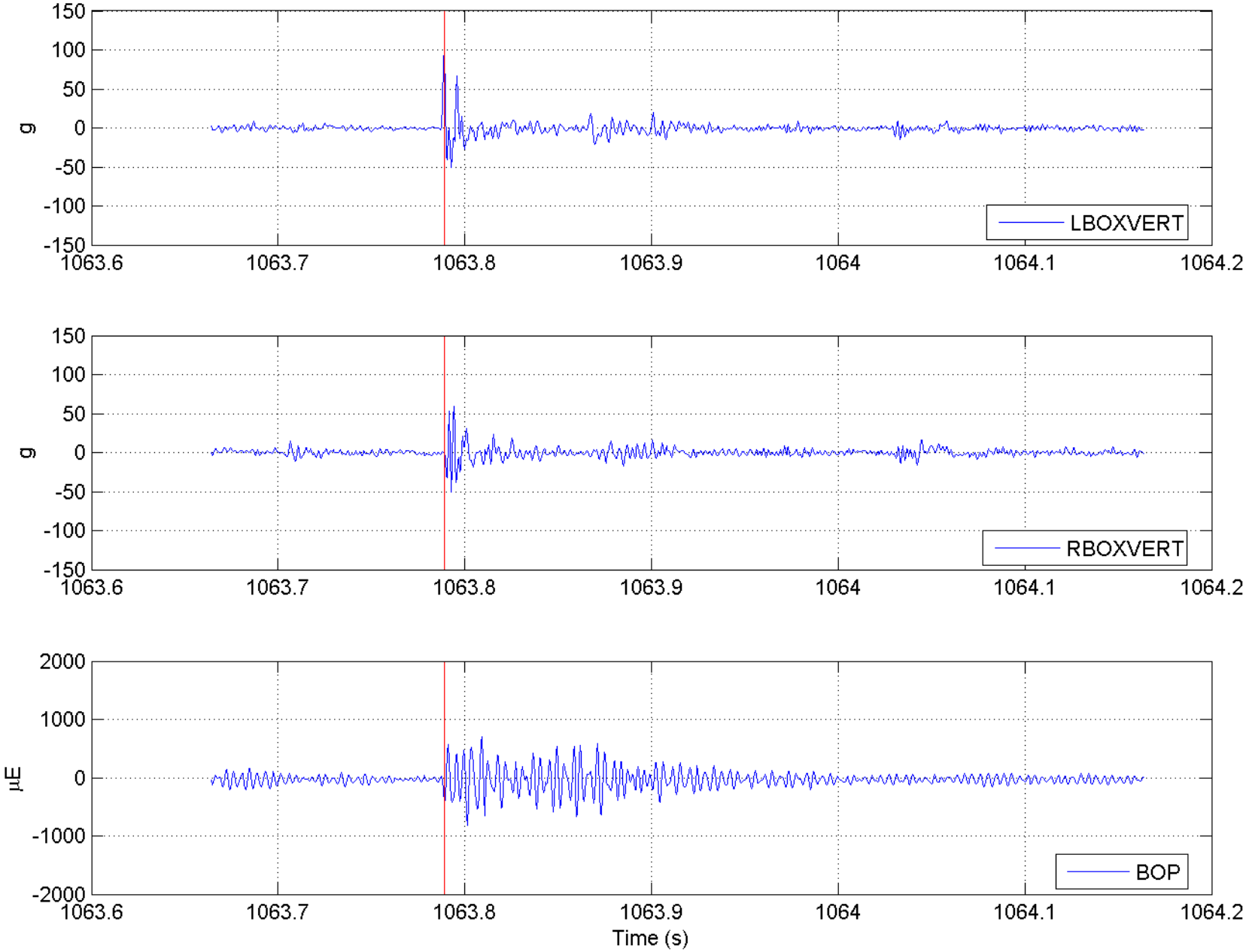
File 051705_19.ABT, Location 906.662 s, LBOXVERT = 117.52 g, RBOXVERT = 39.56 g, BOP = 537.5 uE, Speed = 119.6013 mph, Brake Pressure = 0.891



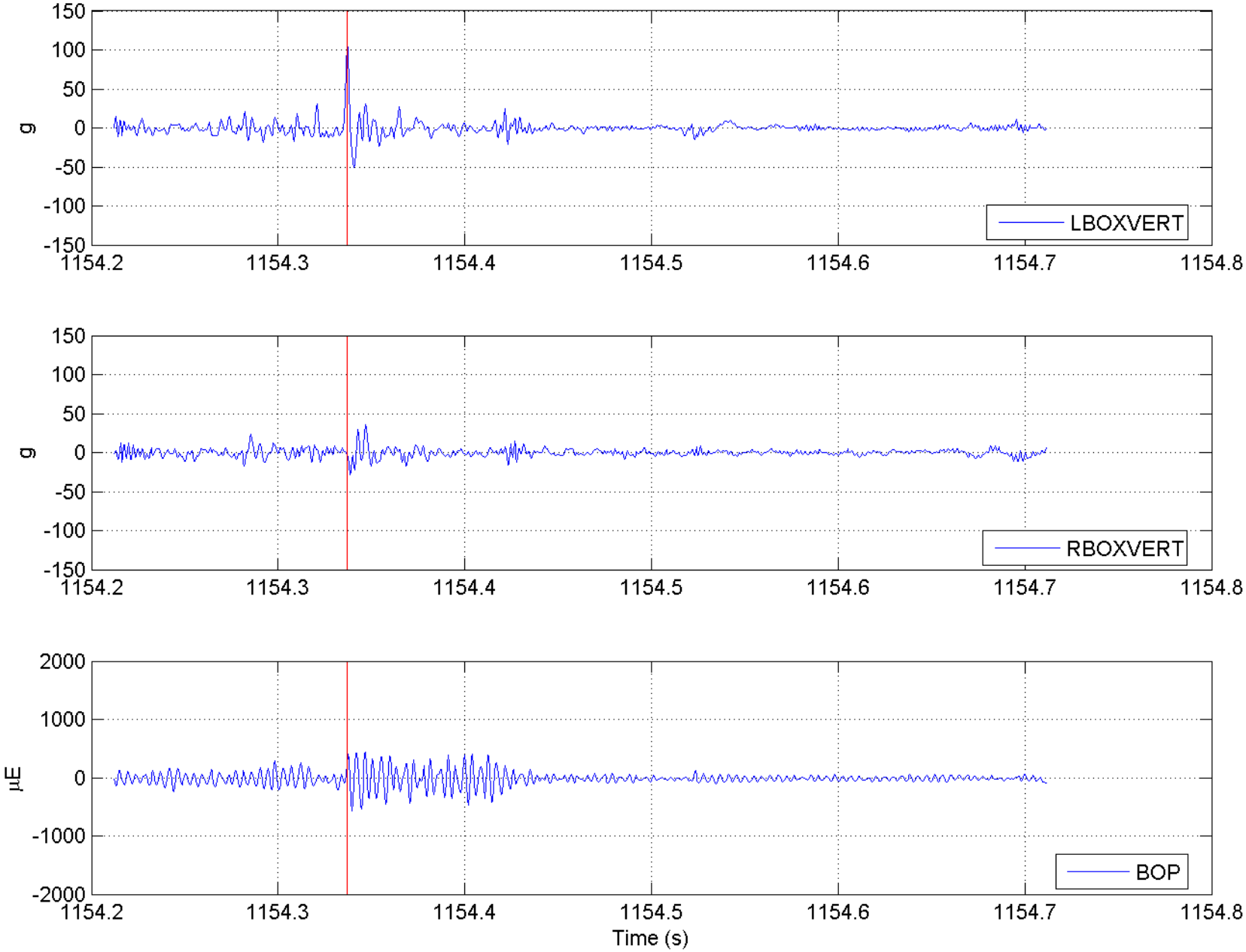
File 051705_19.ABT, Location 2306.5635 s, LBOXVERT = 109.1 g, RBOXVERT = 40.62 g, BOP = 613.5 uE, Speed = 98.8165 mph, Brake Pressure = 0.889



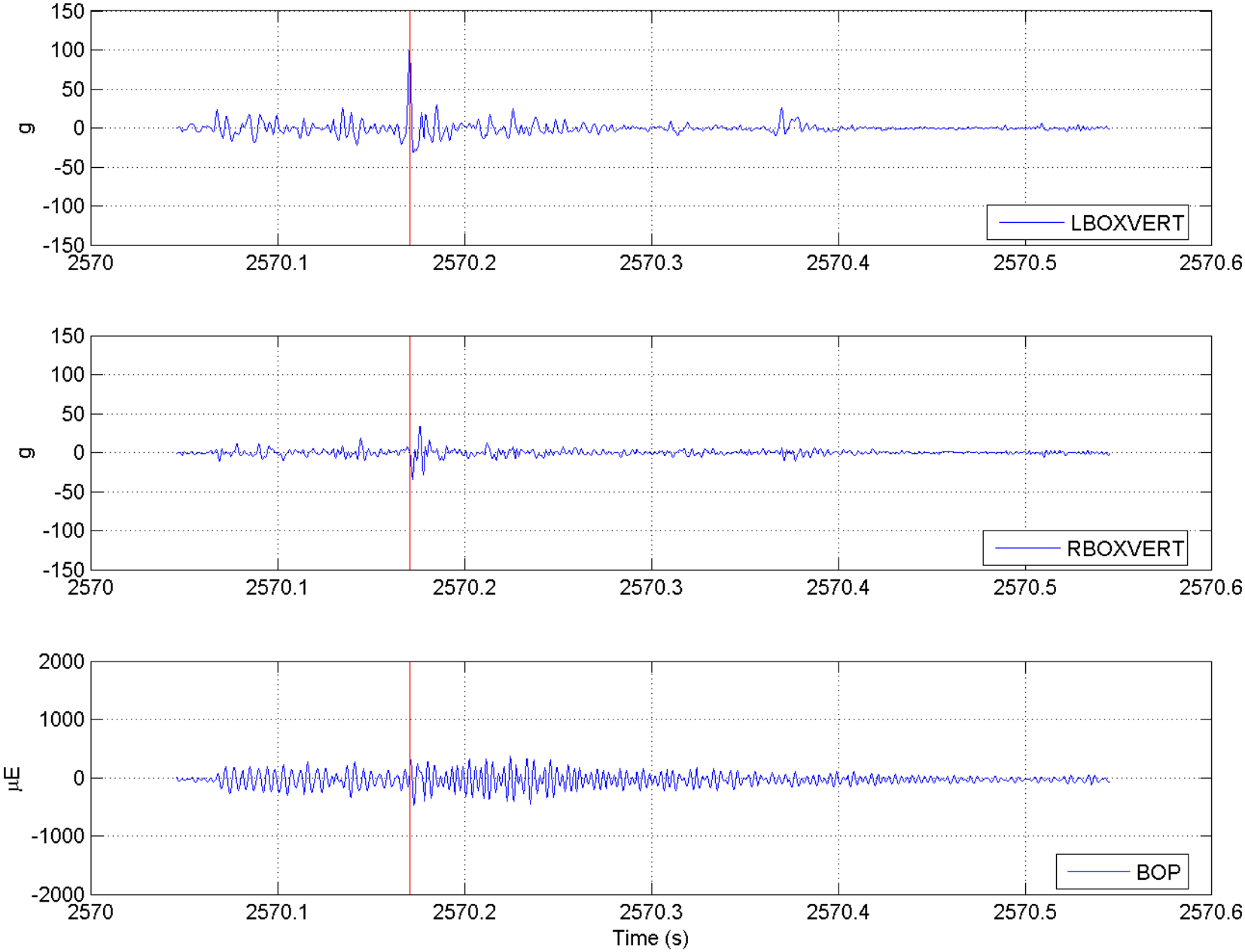
File 051705_21.ABT, Location 1063.789 s, LBOXVERT = 101.53 g, RBOXVERT = 59.48 g, BOP = 817.5 uE, Speed = 89.1118 mph, Brake Pressure = 0.710



ile 051705_21.ABT, Location 1154.337 s, LBOXVERT = 109.83 g, RBOXVERT = 35.85 g, BOP = 563.5 uE, Speed = 124.2255 mph, Brake Pressure = 0.73

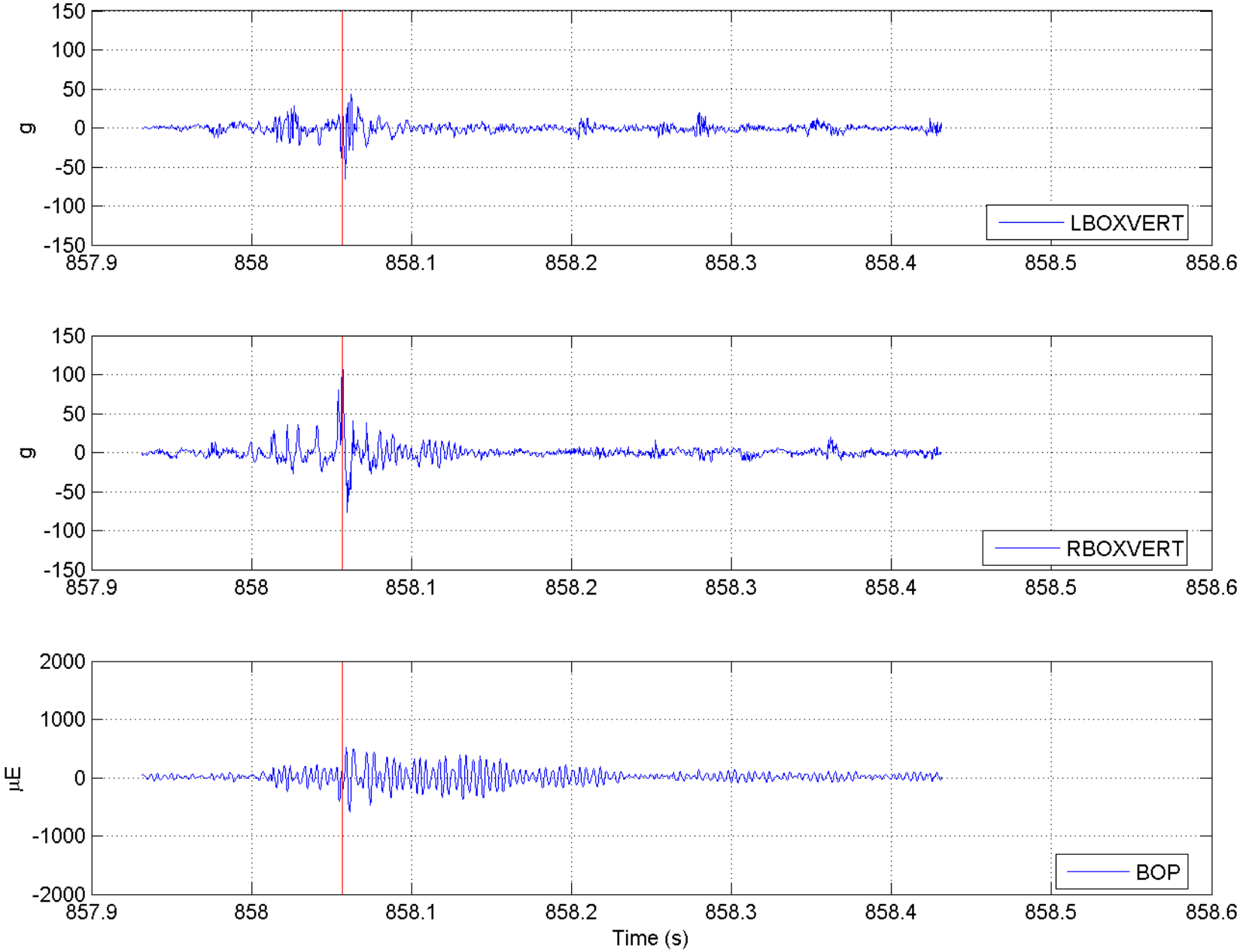


File 051705_21.ABT, Location 2570.1705 s, LBOXVERT = 105.32 g, RBOXVERT = 35.15 g, BOP = 479 uE, Speed = 48.8963 mph, Brake Pressure = 0.723

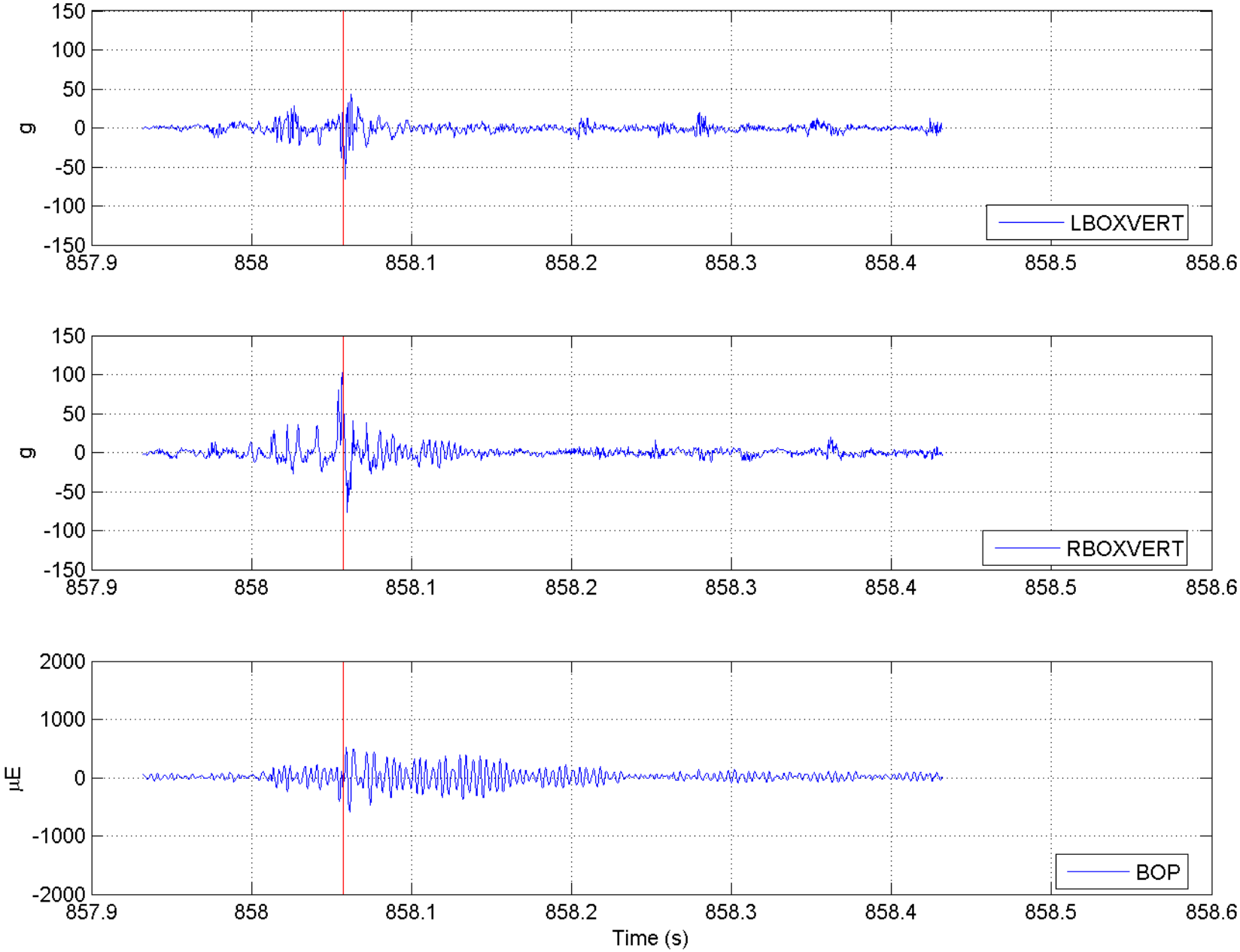


Day 3 – May 26, 2005

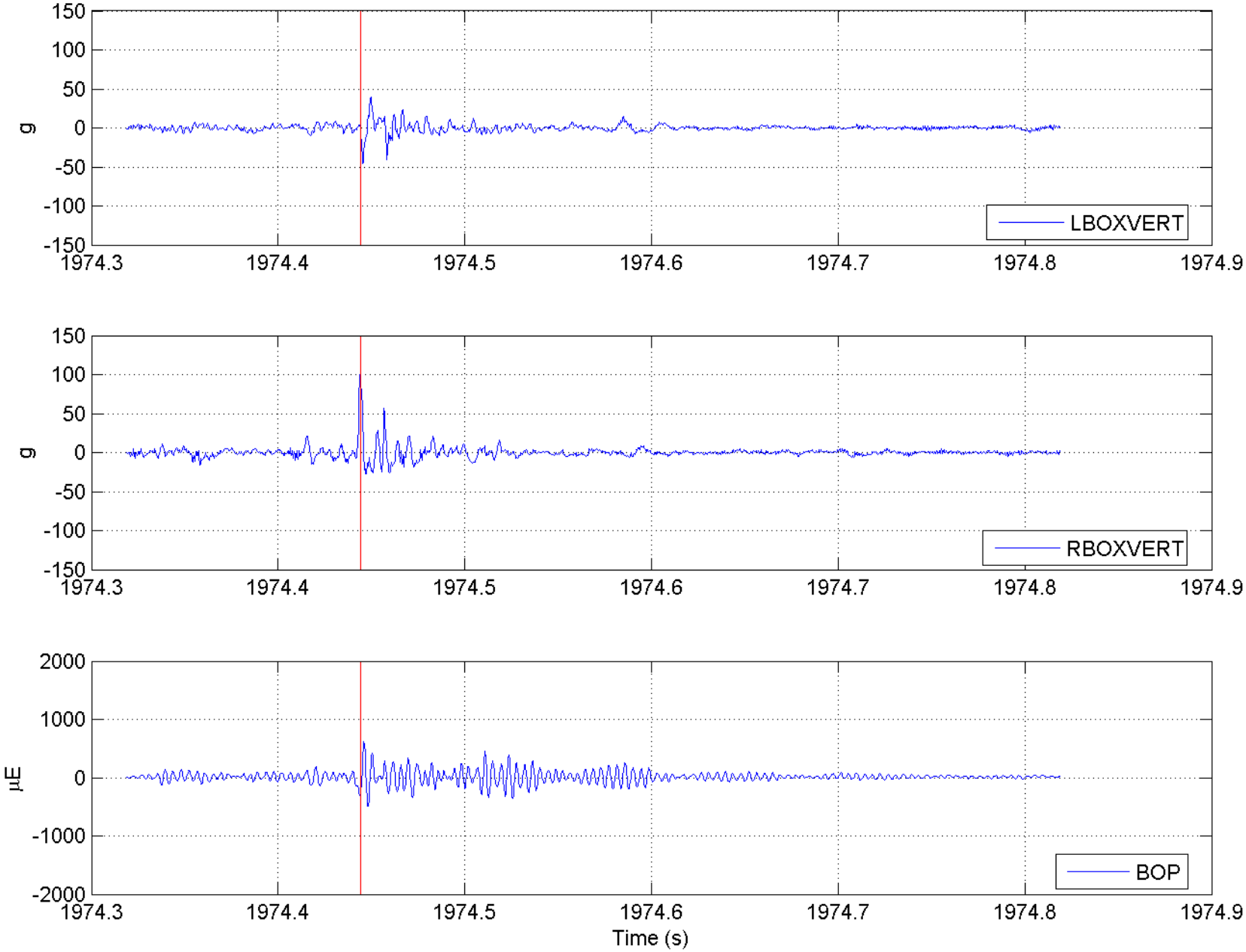
File 052605_02.AB2, Location 858.0567 s, LBOXVERT = 65.13 g, RBOXVERT = 106.67 g, BOP = 580 uE, Speed = 122.6535 mph, Brake Pressure = 2.152



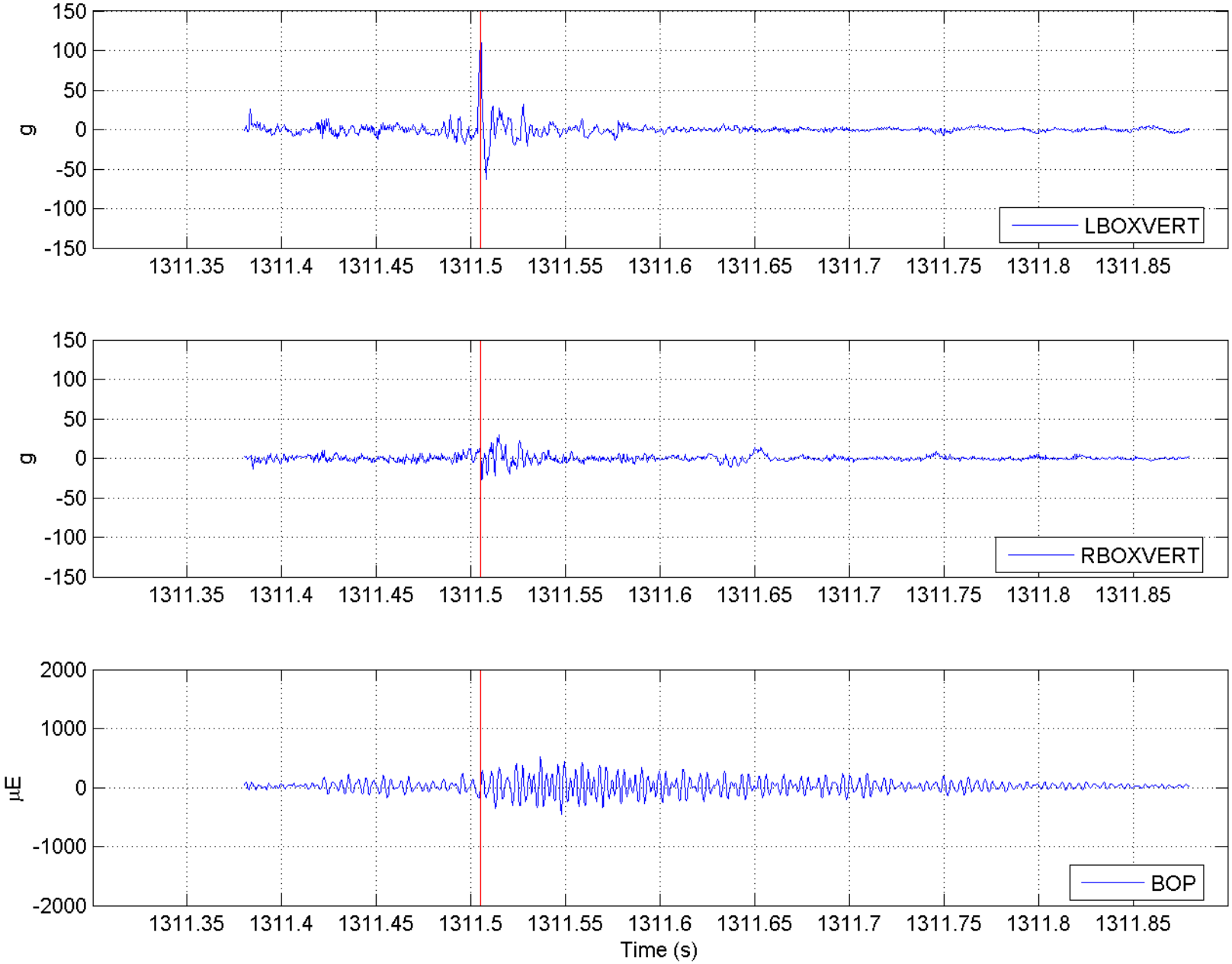
File 052605_02.AB2, Location 858.0573 s, LBOXVERT = 65.13 g, RBOXVERT = 106.67 g, BOP = 580 uE, Speed = 122.6598 mph, Brake Pressure = 2.152



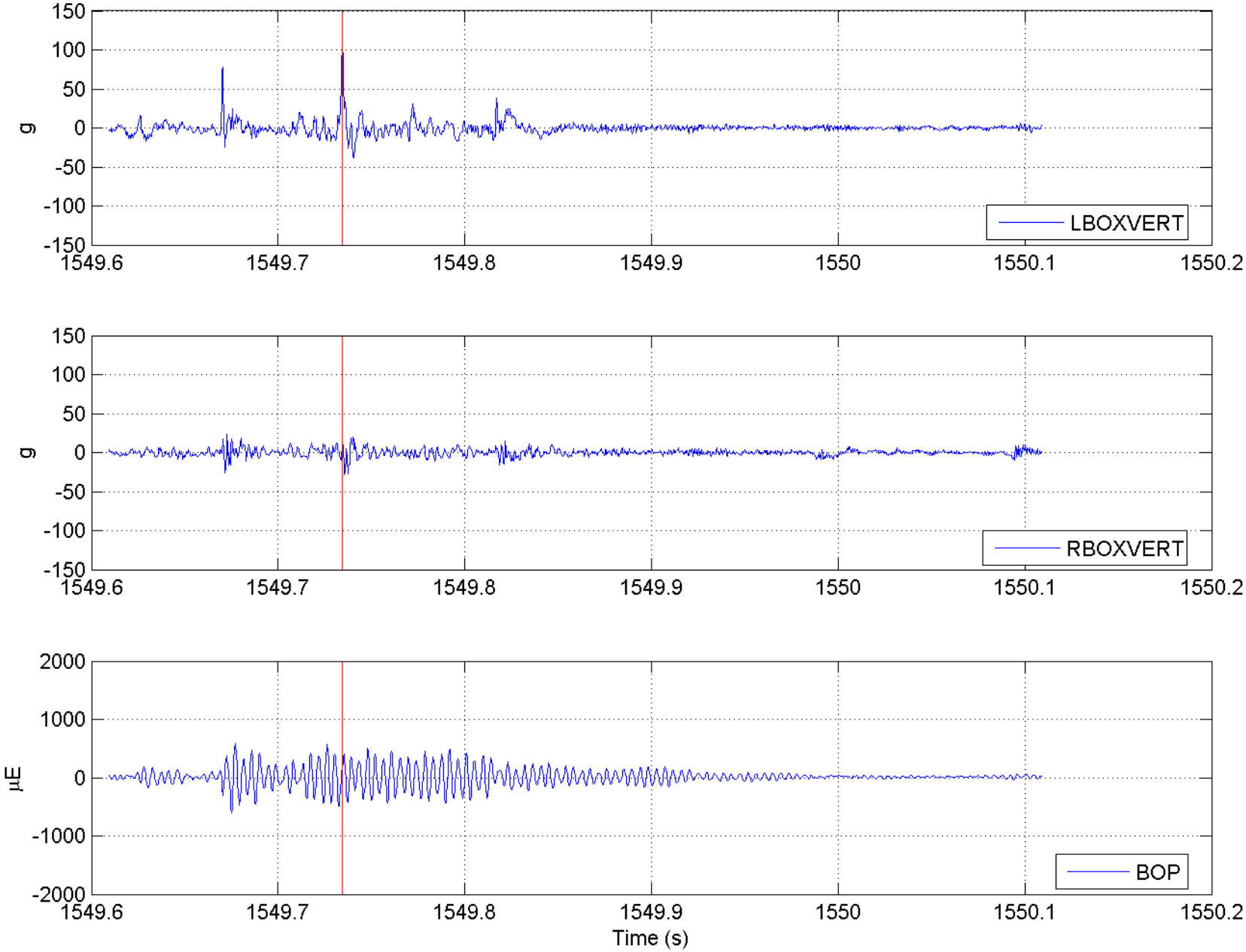
File 052605_02.AB2, Location 1974.444 s, LBOXVERT = 45.72 g, RBOXVERT = 102.28 g, BOP = 620 uE, Speed = 127.5898 mph, Brake Pressure = 0.984



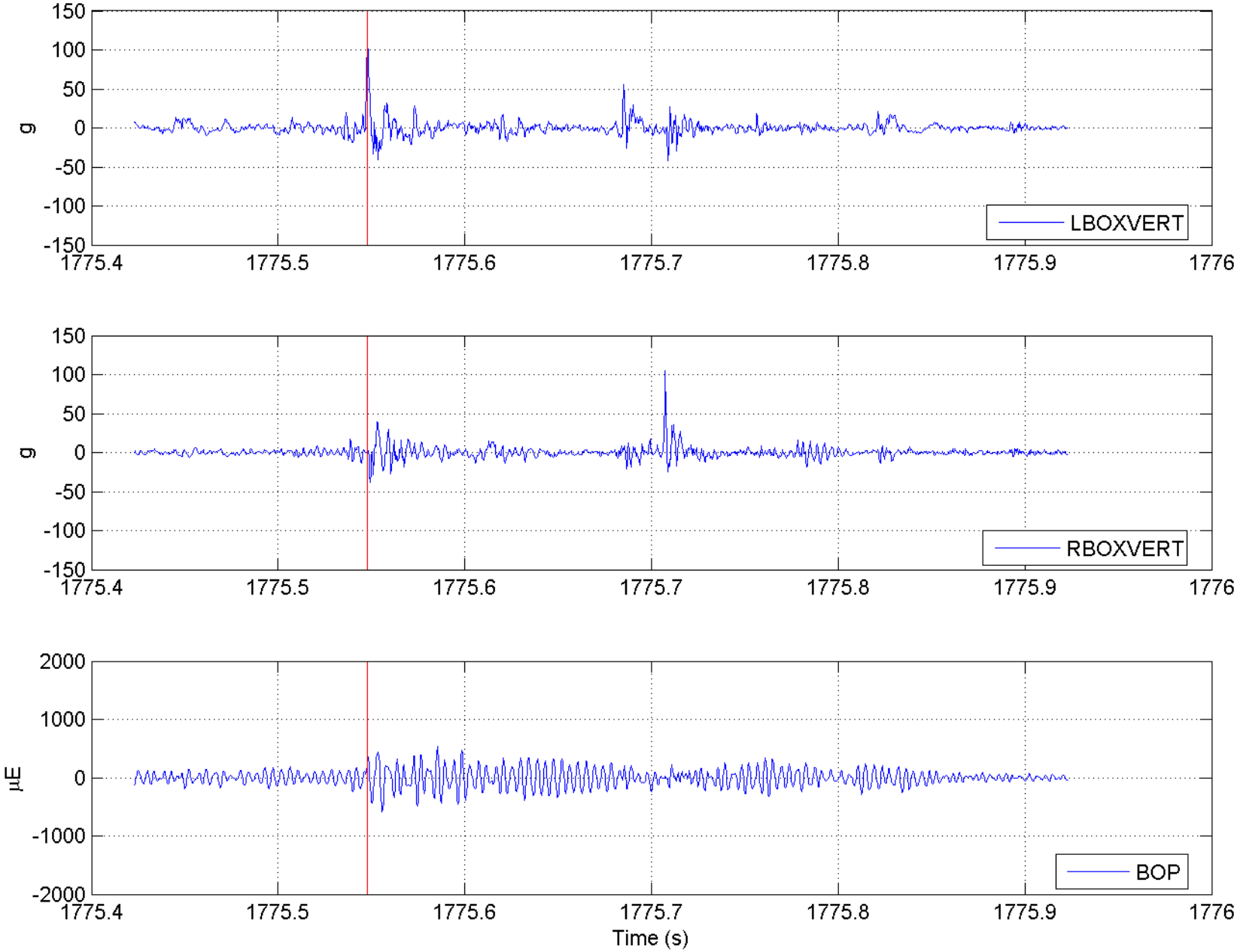
File 052605_05.AB2, Location 1311.505 s, LBOXVERT = 111.39 g, RBOXVERT = 30.01 g, BOP = 523.5 uE, Speed = 130.489 mph, Brake Pressure = 0.812



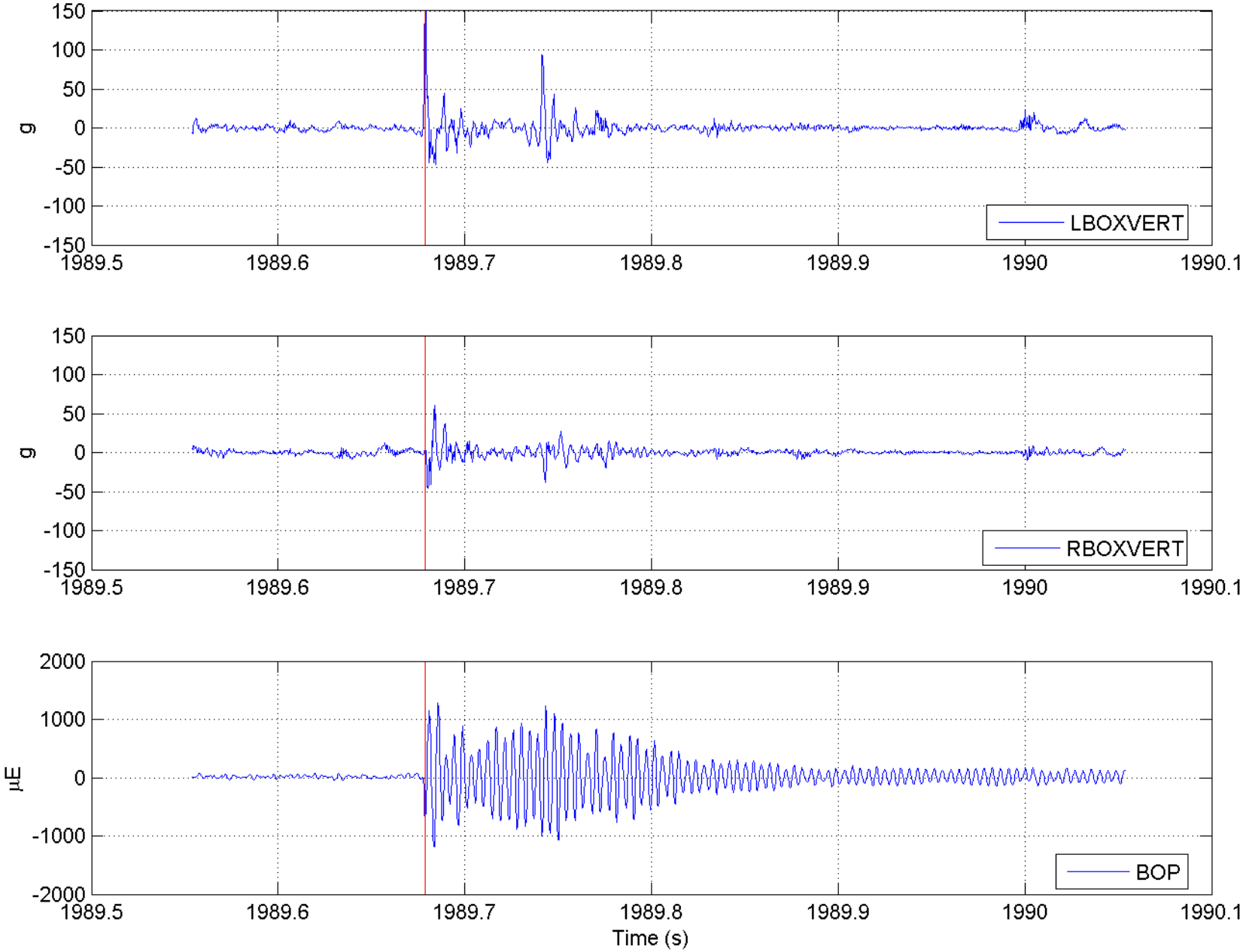
le 052605_05.AB2, Location 1549.7343 s, LBOXVERT = 102.23 g, RBOXVERT = 28.46 g, BOP = 598.5 uE, Speed = 124.5957 mph, Brake Pressure = 0.80



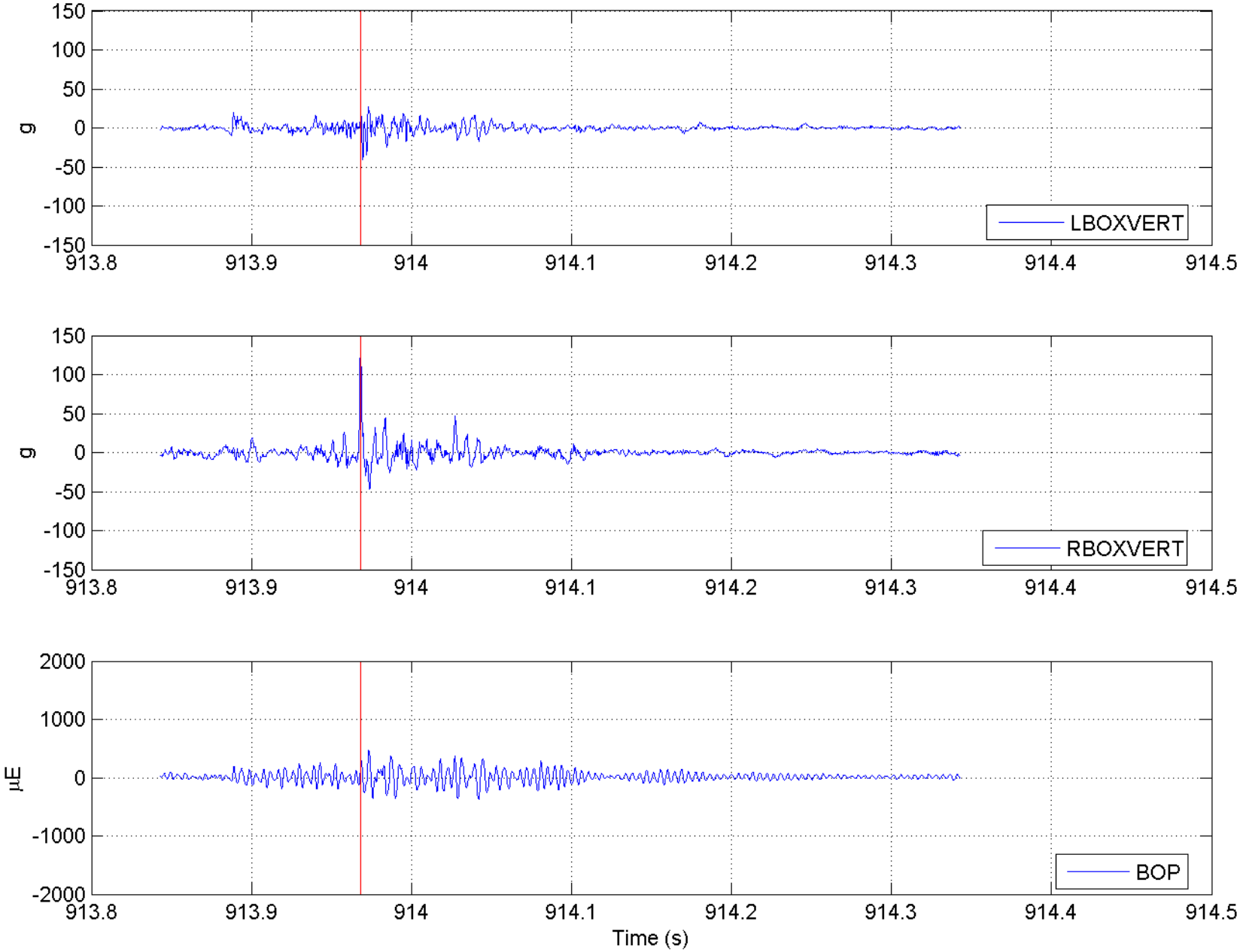
File 052605_05.AB2, Location 1775.548 s, LBOXVERT = 124.08 g, RBOXVERT = 104.6 g, BOP = 588.5 uE, Speed = 97.148 mph, Brake Pressure = 0.807



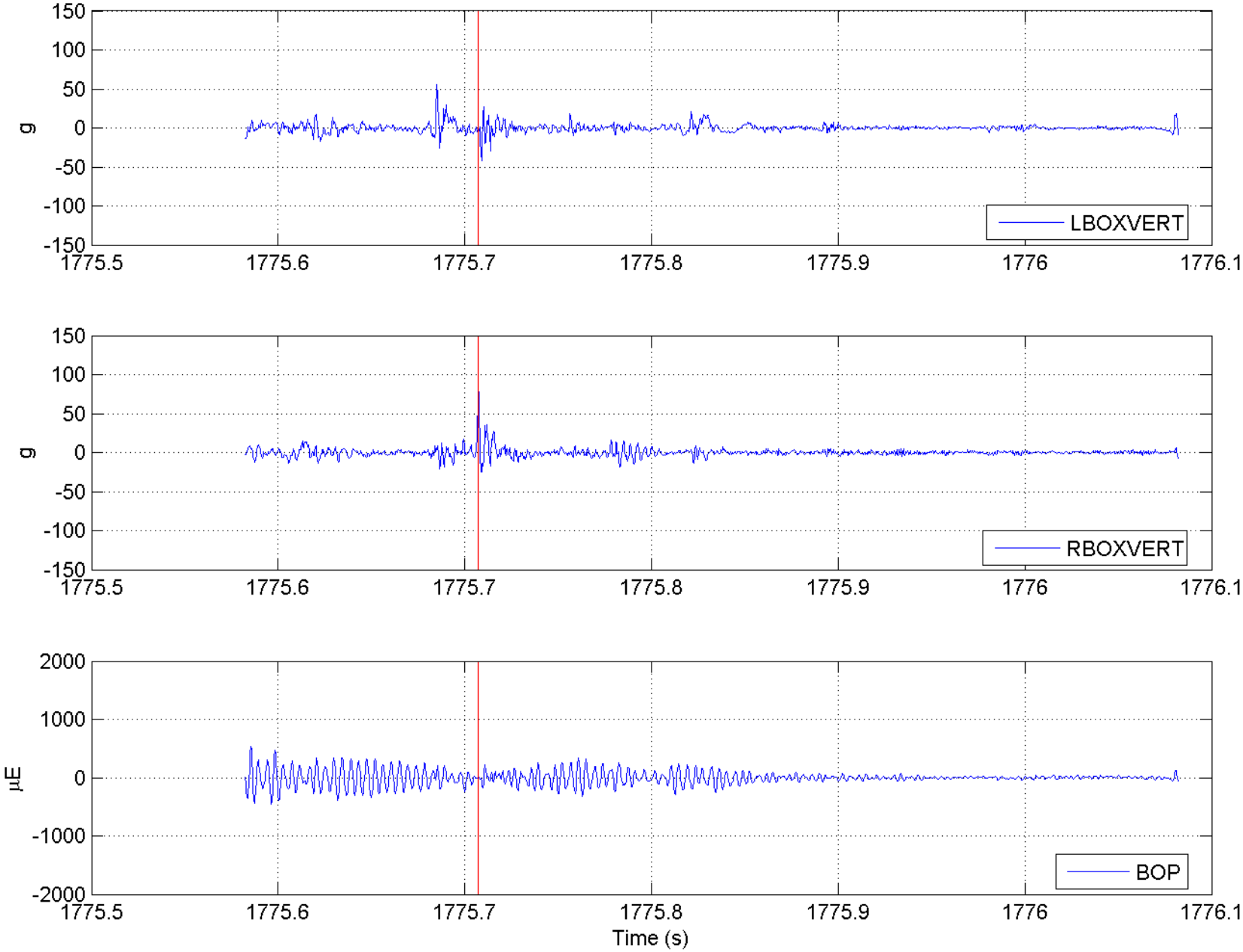
le 052605_05.AB2, Location 1989.679 s, LBOXVERT = 155.58 g, RBOXVERT = 60.16 g, BOP = 1278.5 uE, Speed = 112.6491 mph, Brake Pressure = 0.80



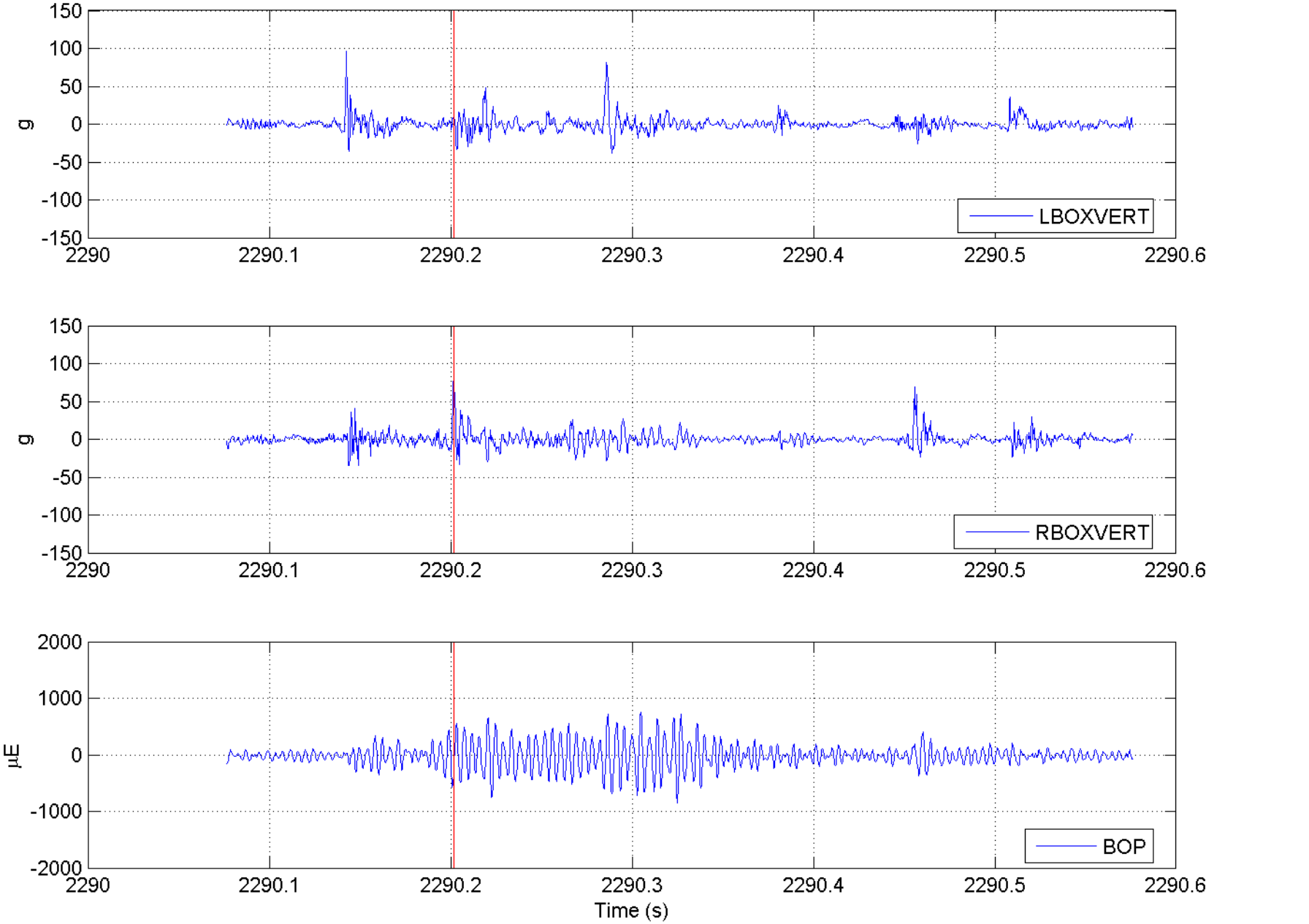
File 052605_05.AB2, Location 913.968 s, LBOXVERT = 41.08 g, RBOXVERT = 129.74 g, BOP = 474.5 uE, Speed = 108.2172 mph, Brake Pressure = 0.790



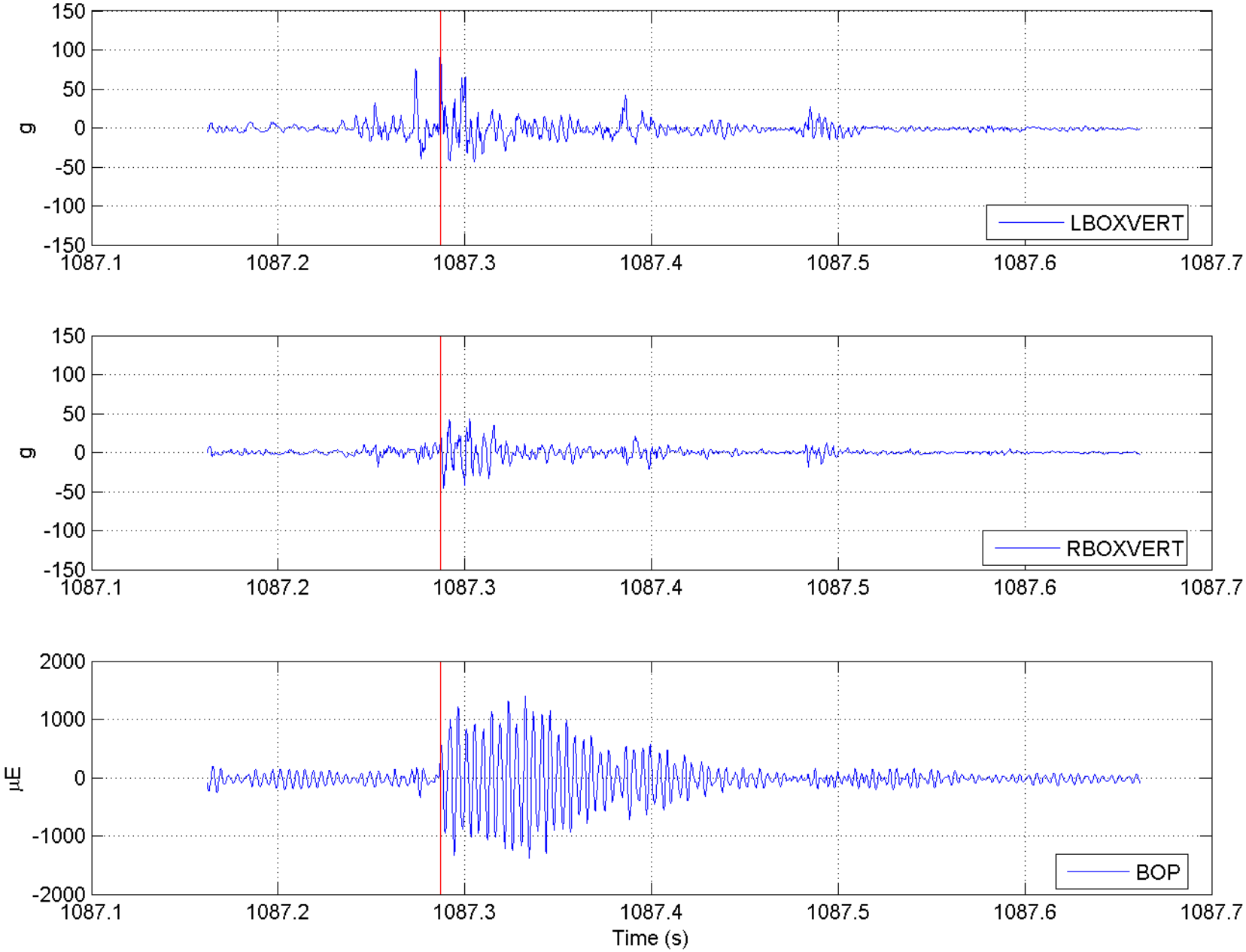
File 052605_05.AB2, Location 1775.7073 s, LBOXVERT = 55.48 g, RBOXVERT = 104.6 g, BOP = 530.5 uE, Speed = 97.0837 mph, Brake Pressure = 0.810



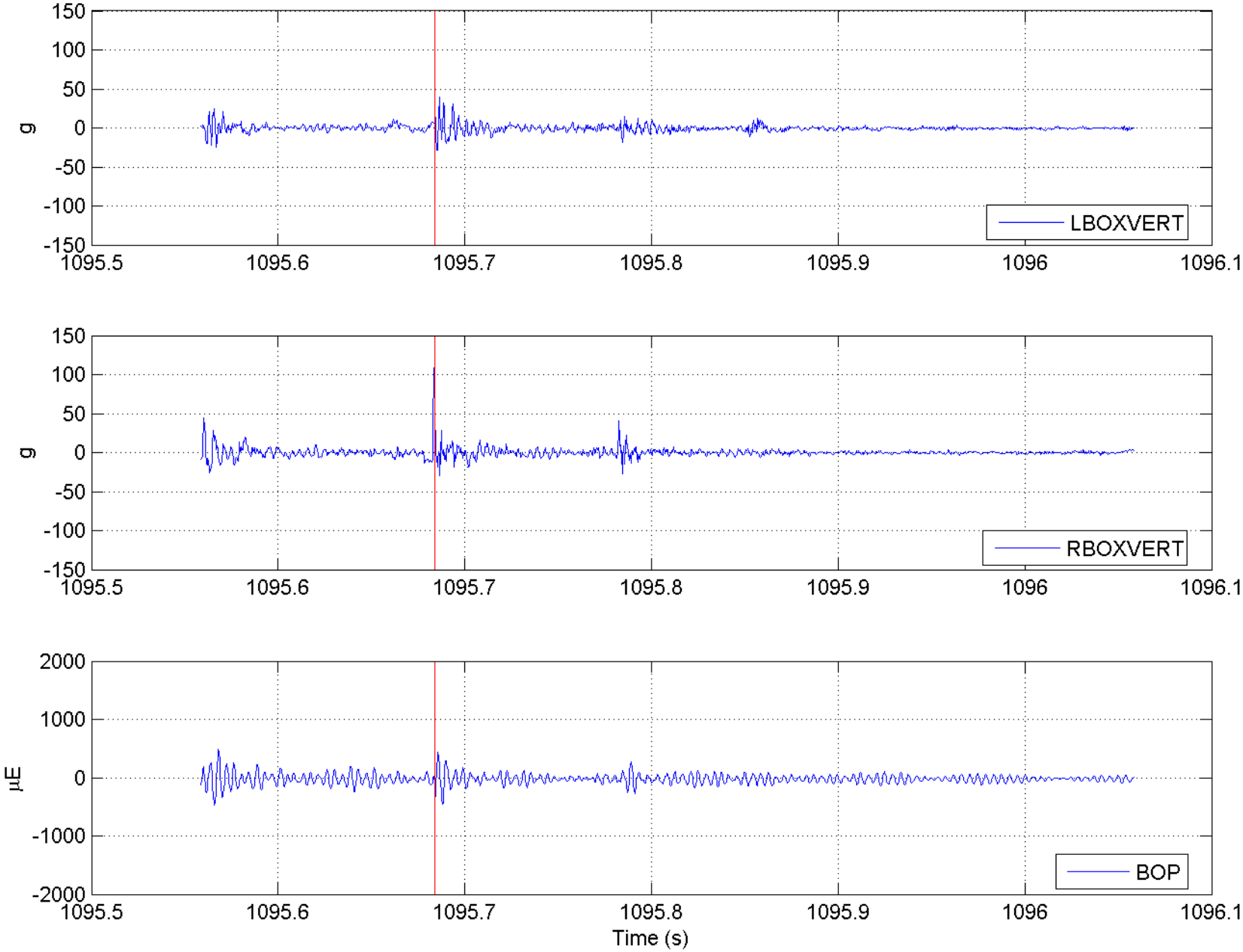
e 052605_05.AB2, Location 2290.2013 s, LBOXVERT = 96.62 g, RBOXVERT = 101.91 g, BOP = 853.5 uE, Speed = 107.3382 mph, Brake Pressure = 0.80



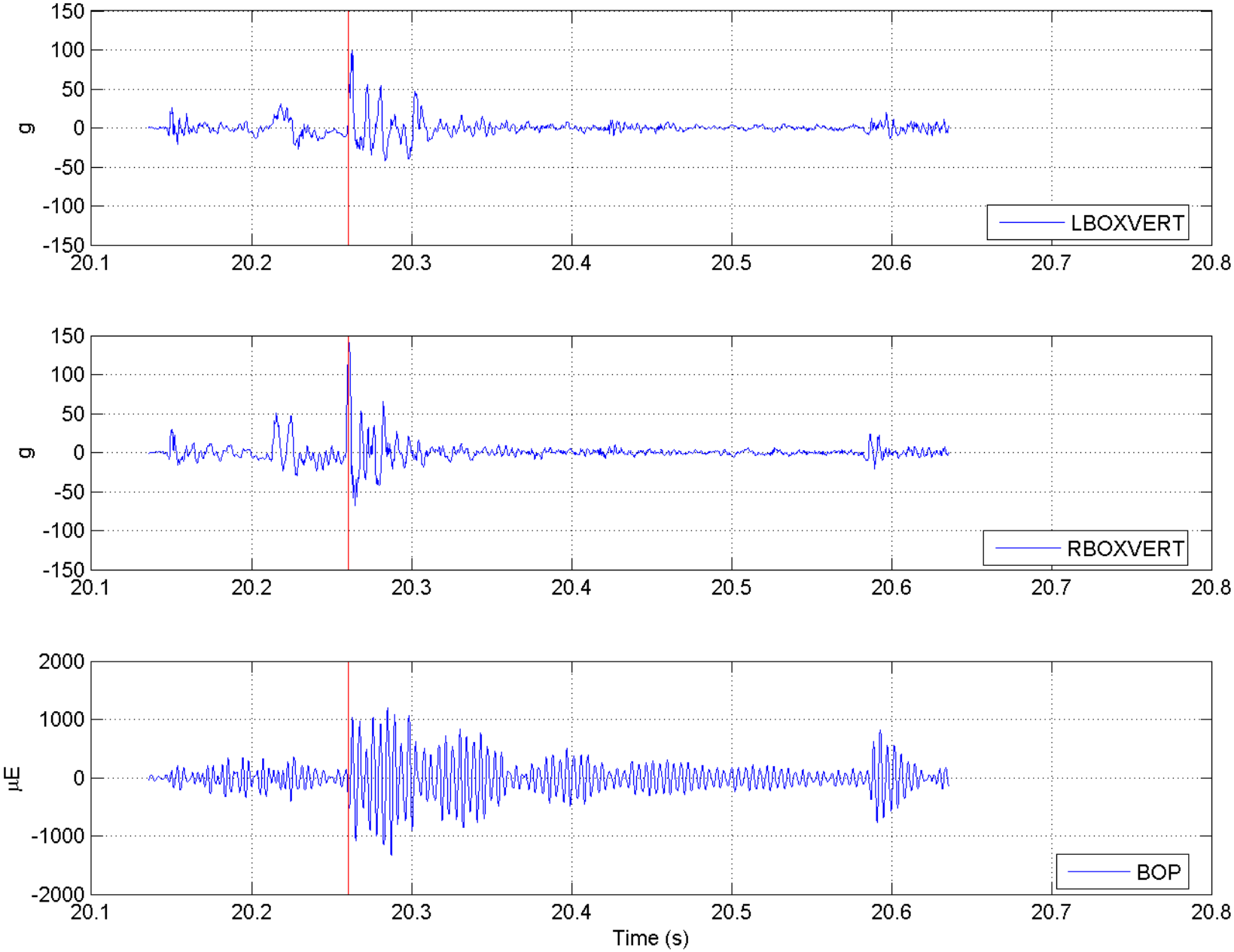
ile 052605_08.AB2, Location 1087.287 s, LBOXVERT = 104.43 g, RBOXVERT = 45.43 g, BOP = 1404.5 uE, Speed = 70.1026 mph, Brake Pressure = 0.788



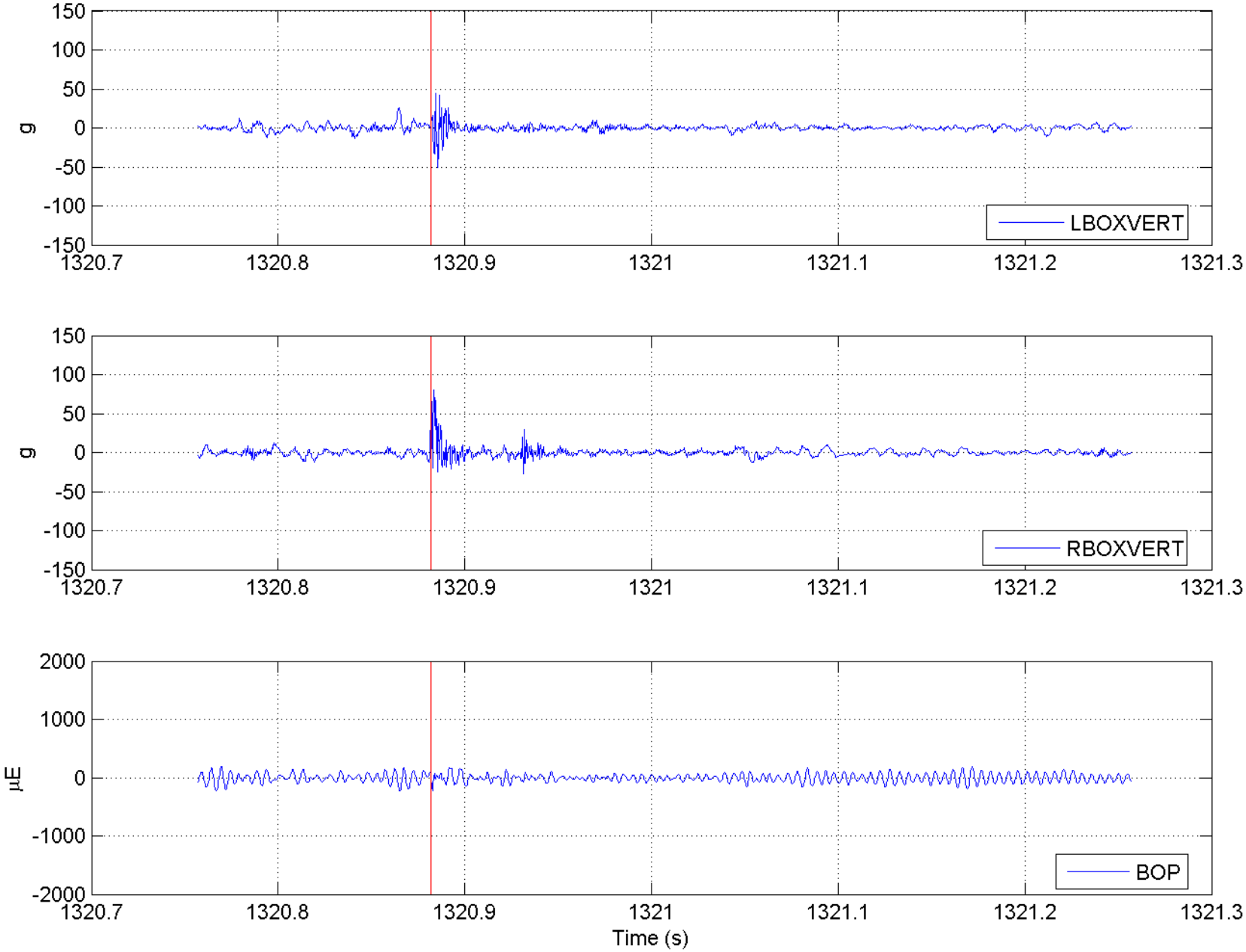
File 052605_08.AB2, Location 1095.6837 s, LBOXVERT = 39.37 g, RBOXVERT = 111.8 g, BOP = 486 uE, Speed = 69.2645 mph, Brake Pressure = 0.7818



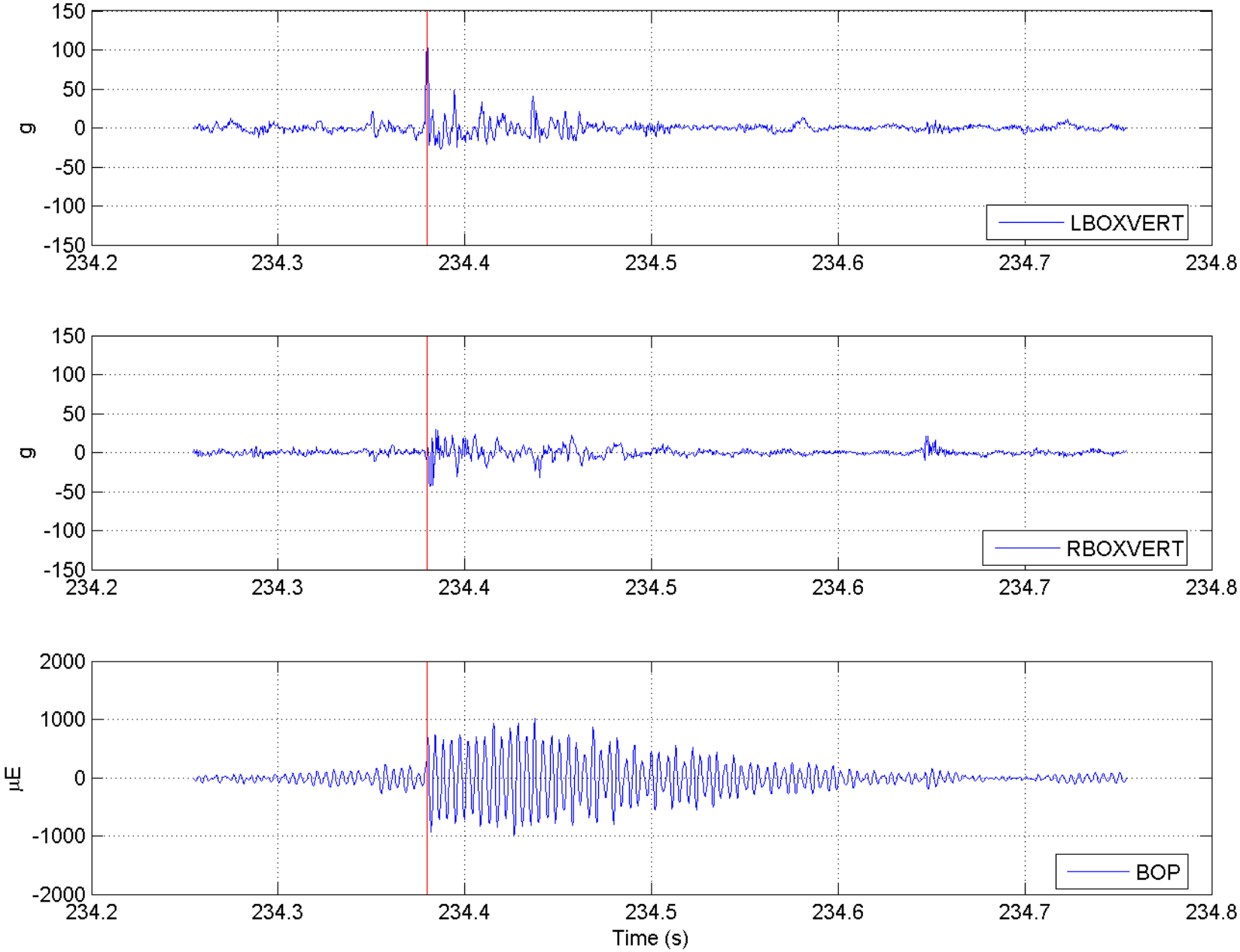
File 052605_09.AB2, Location 20.2607 s, LBOXVERT = 98.45 g, RBOXVERT = 141.22 g, BOP = 1327 uE, Speed = 42.9927 mph, Brake Pressure = 0.6149



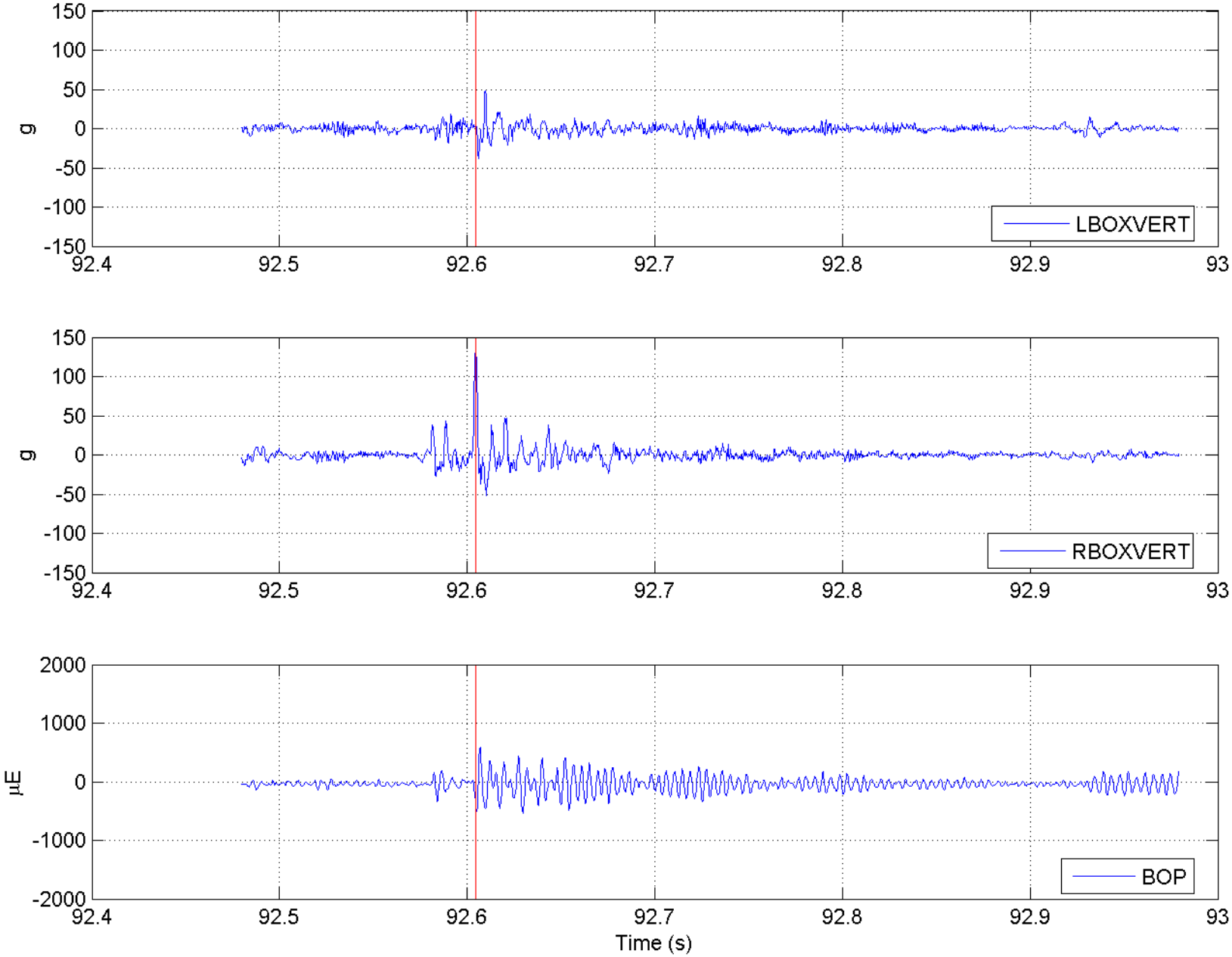
File 052605_15.AB2, Location 1320.882 s, LBOXVERT = 50.23 g, RBOXVERT = 103.25 g, BOP = 229 uE, Speed = 143.0115 mph, Brake Pressure = 24.14



File 052605_18.AB2, Location 234.3797 s, LBOXVERT = 116.64 g, RBOXVERT = 43.11 g, BOP = 1015 uE, Speed = 120.264 mph, Brake Pressure = 0.788

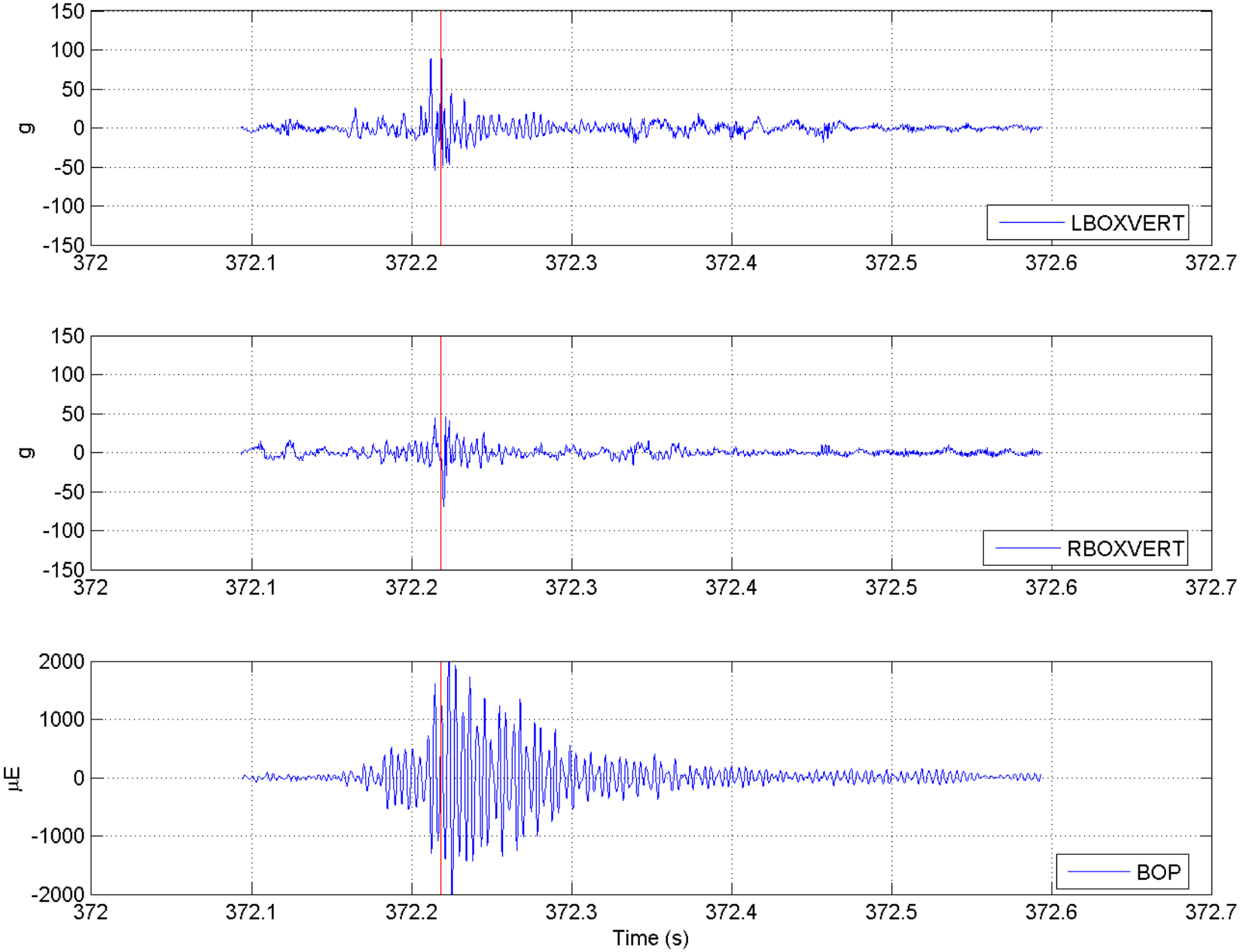


File 052605_18.AB2, Location 92.6047 s, LBOXVERT = 48.4 g, RBOXVERT = 145 g, BOP = 584.5 uE, Speed = 108.4899 mph, Brake Pressure = 0.80407

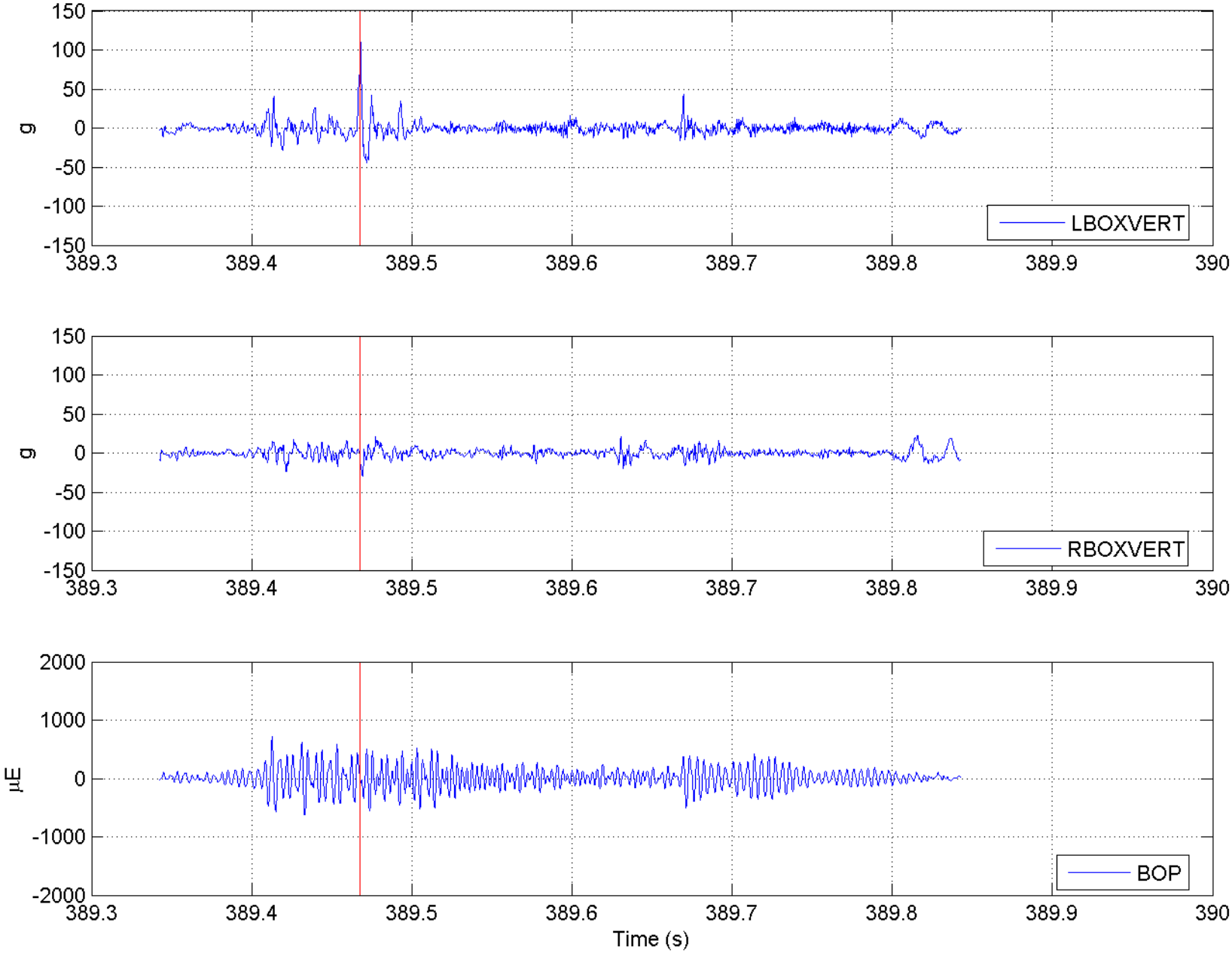


Day 4 – May 27, 2005

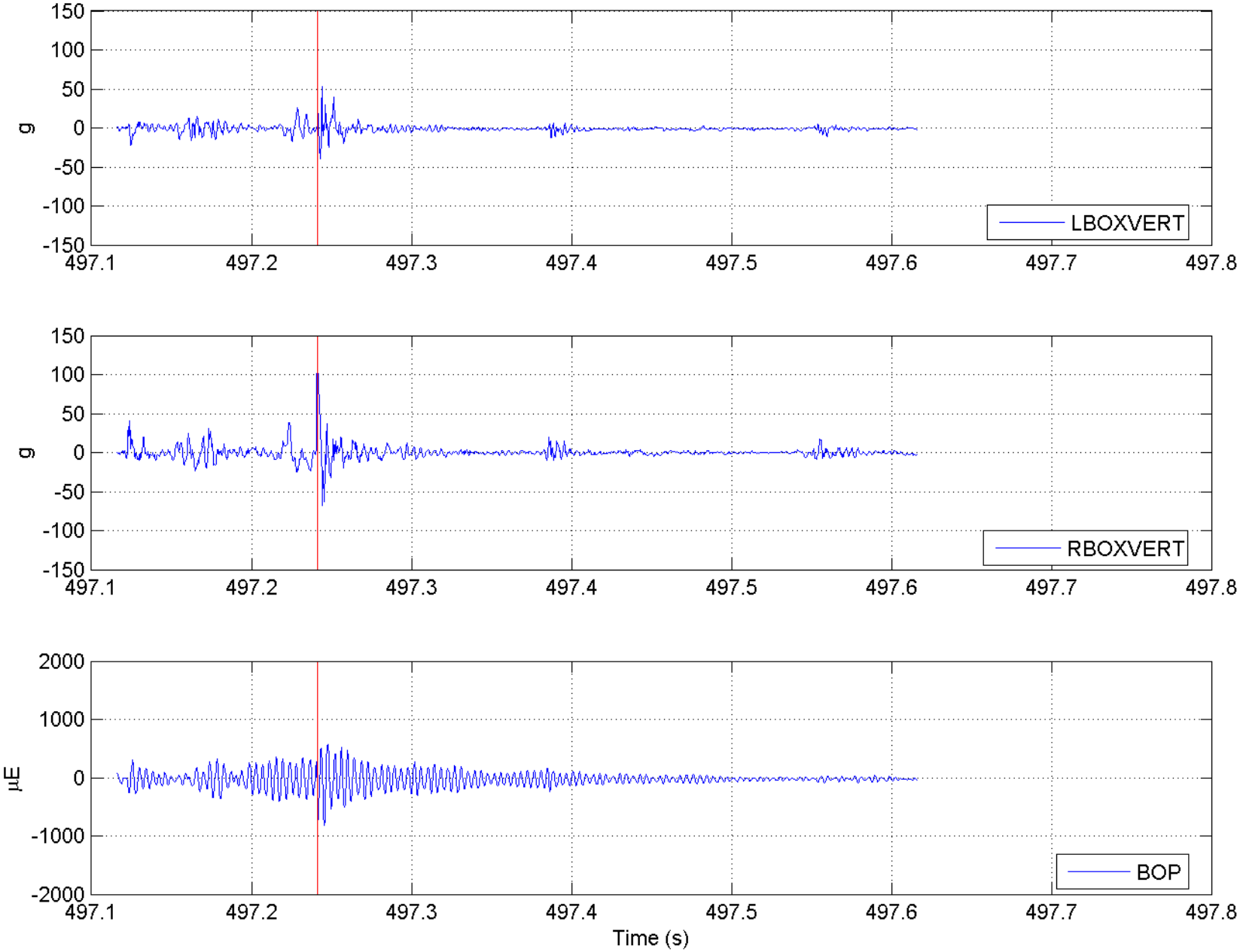
File 052705_01.AB2, Location 372.2183 s, LBOXVERT = 101.64 g, RBOXVERT = 69.54 g, BOP = 2258 uE, Speed = 120.1375 mph, Brake Pressure = 1.20



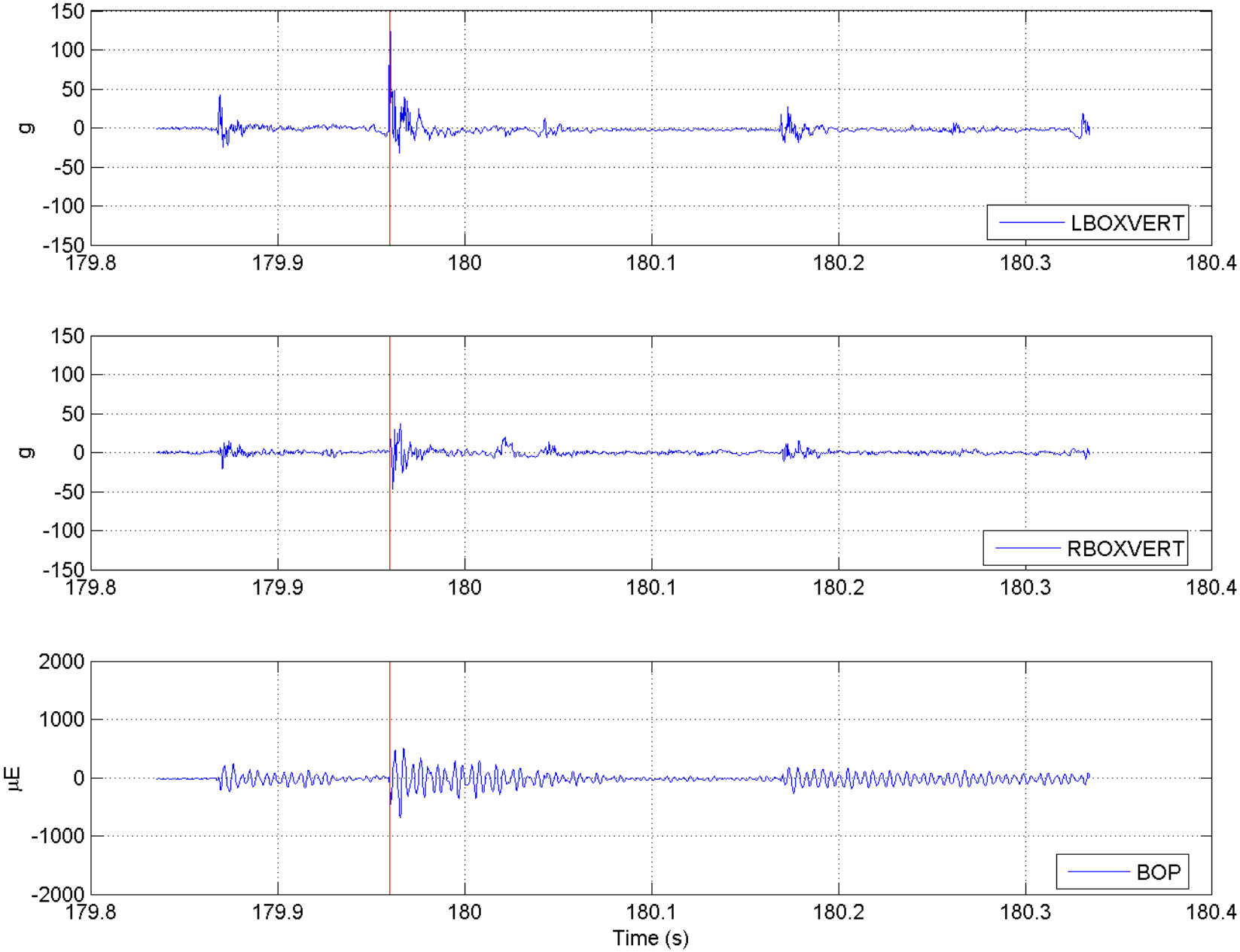
File 052705_01.AB2, Location 389.4677 s, LBOXVERT = 112.38 g, RBOXVERT = 29.86 g, BOP = 711.5 uE, Speed = 119.1653 mph, Brake Pressure = 1.18



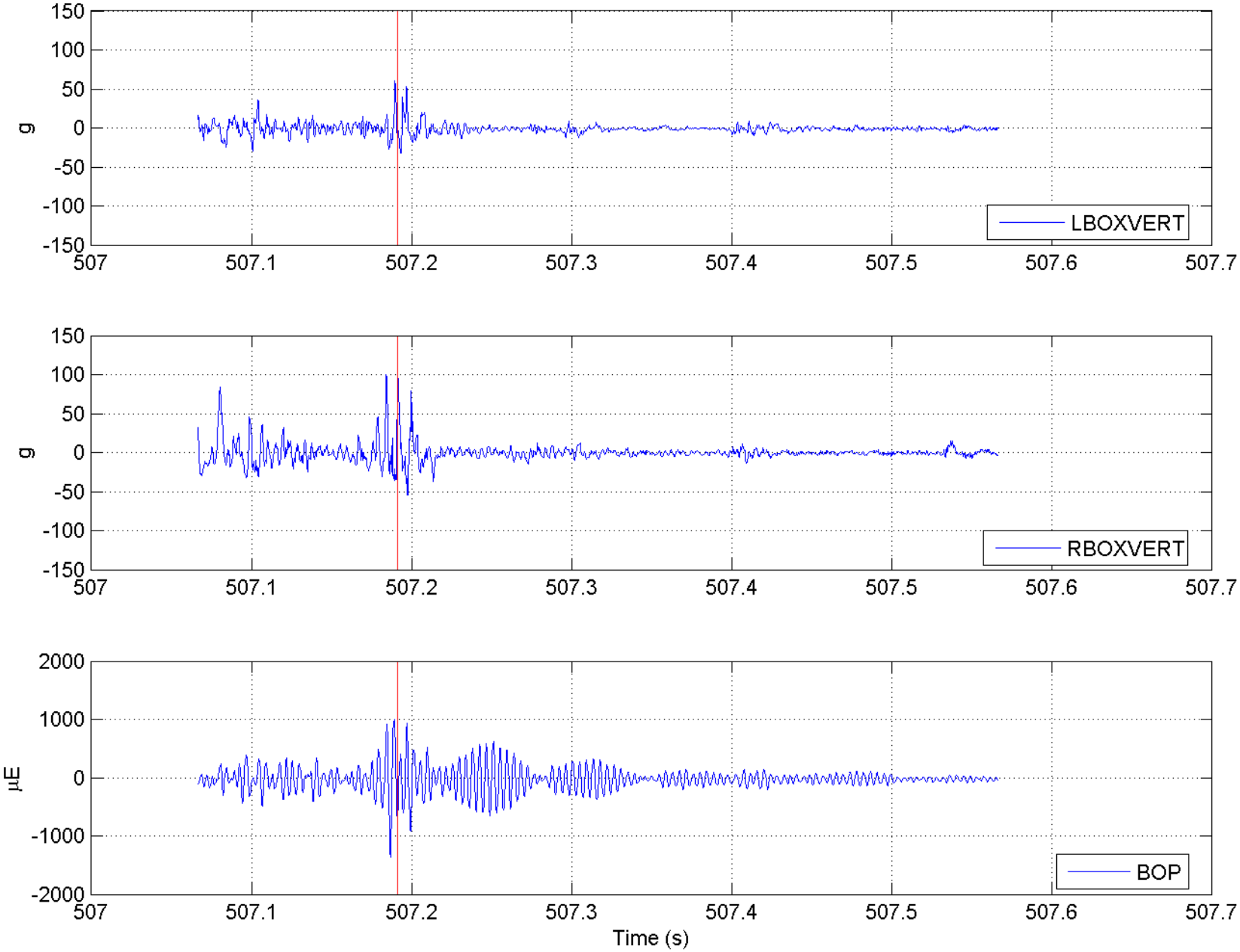
File 052705_12.AB2, Location 497.241 s, LBOXVERT = 52.81 g, RBOXVERT = 132.25 g, BOP = 813.5 uE, Speed = 47.9847 mph, Brake Pressure = 1.353



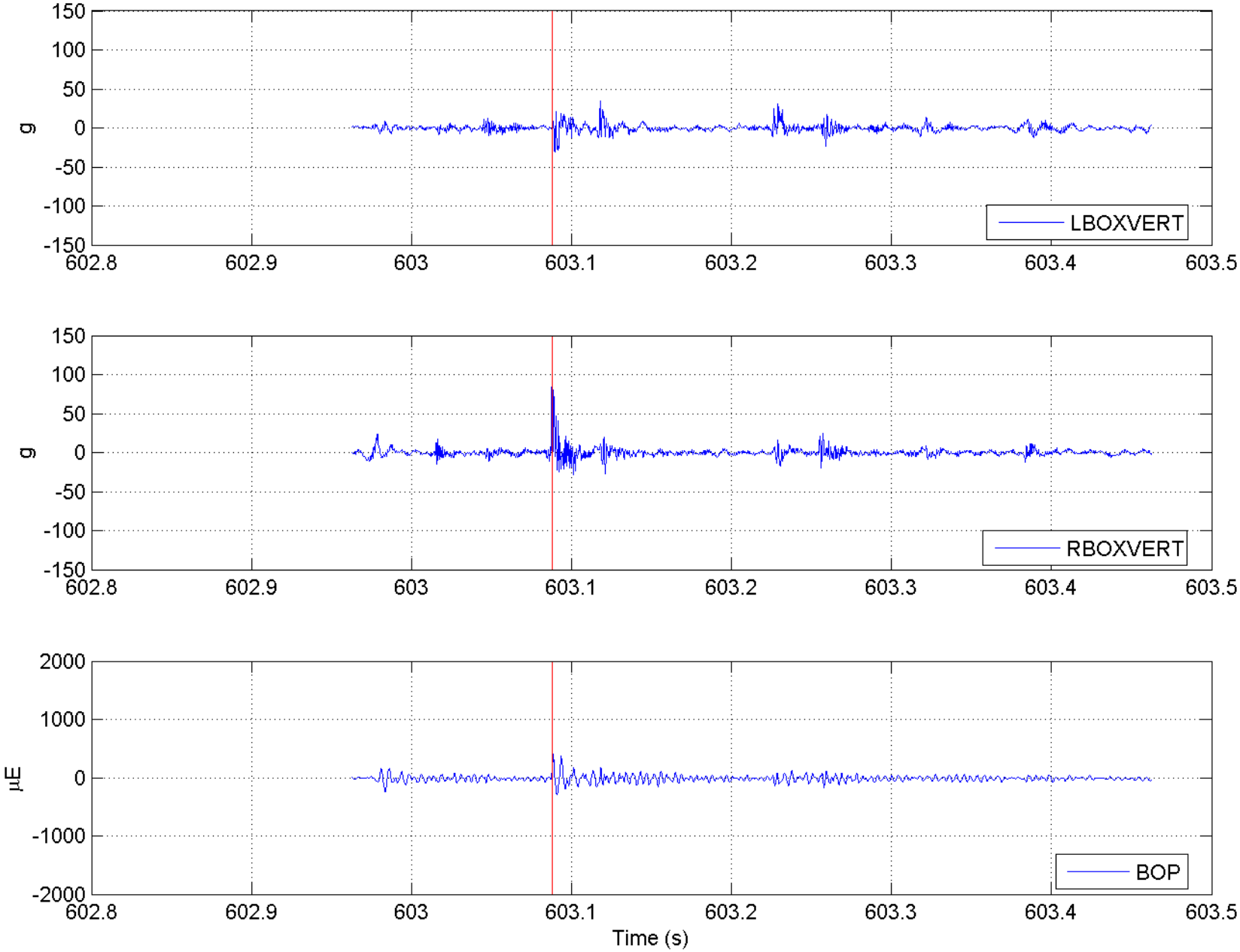
File 052705_13.AB2, Location 179.9597 s, LBOXVERT = 132.28 g, RBOXVERT = 47.32 g, BOP = 690 uE, Speed = 71.5146 mph, Brake Pressure = 1.335



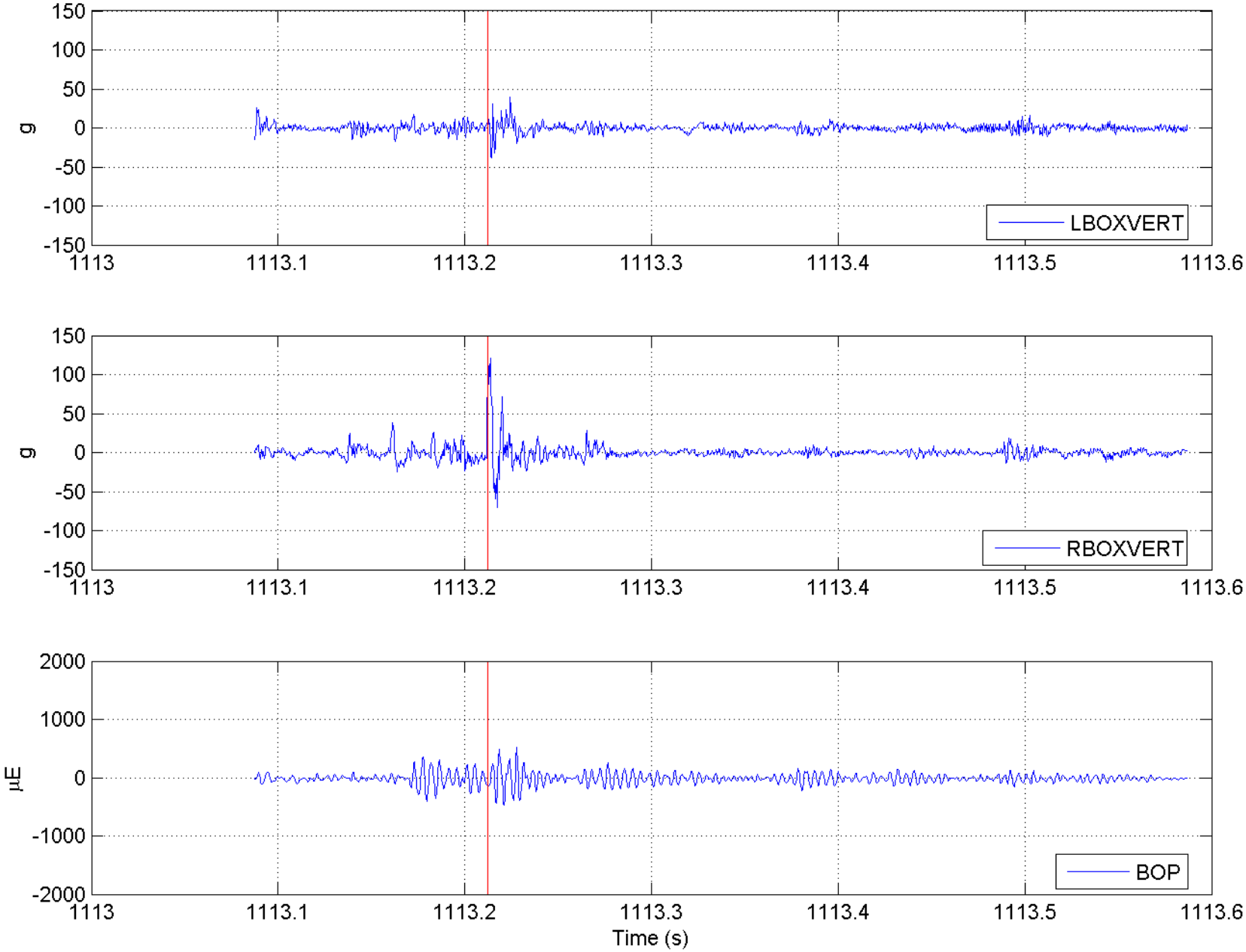
File 052705_13.AB2, Location 507.1913 s, LBOXVERT = 60.75 g, RBOXVERT = 108.81 g, BOP = 1358.5 uE, Speed = 69.2533 mph, Brake Pressure = 1.36



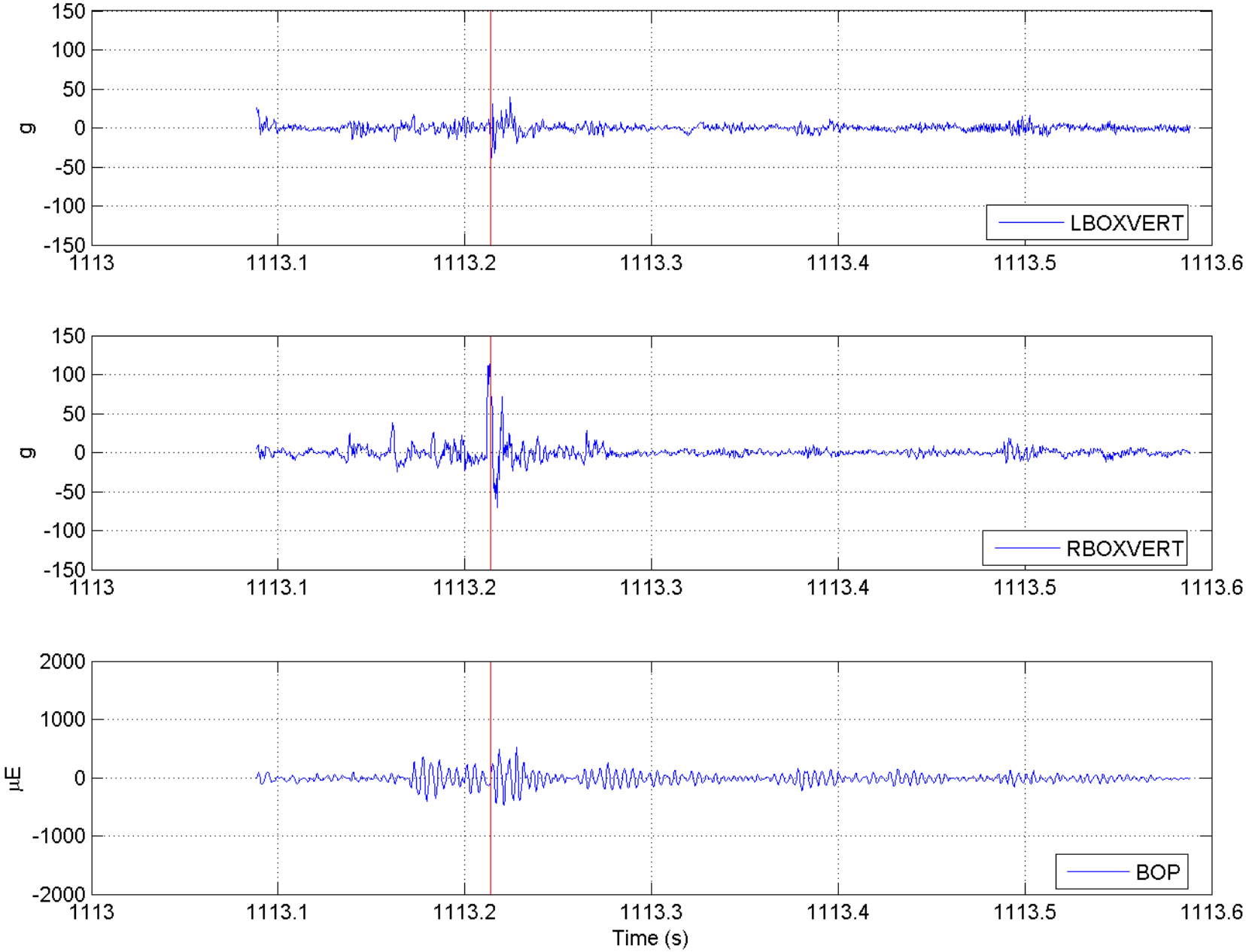
File 052705_19.AB2, Location 603.088 s, LBOXVERT = 34.87 g, RBOXVERT = 113.45 g, BOP = 400 uE, Speed = 90.08 mph, Brake Pressure = 1.5228



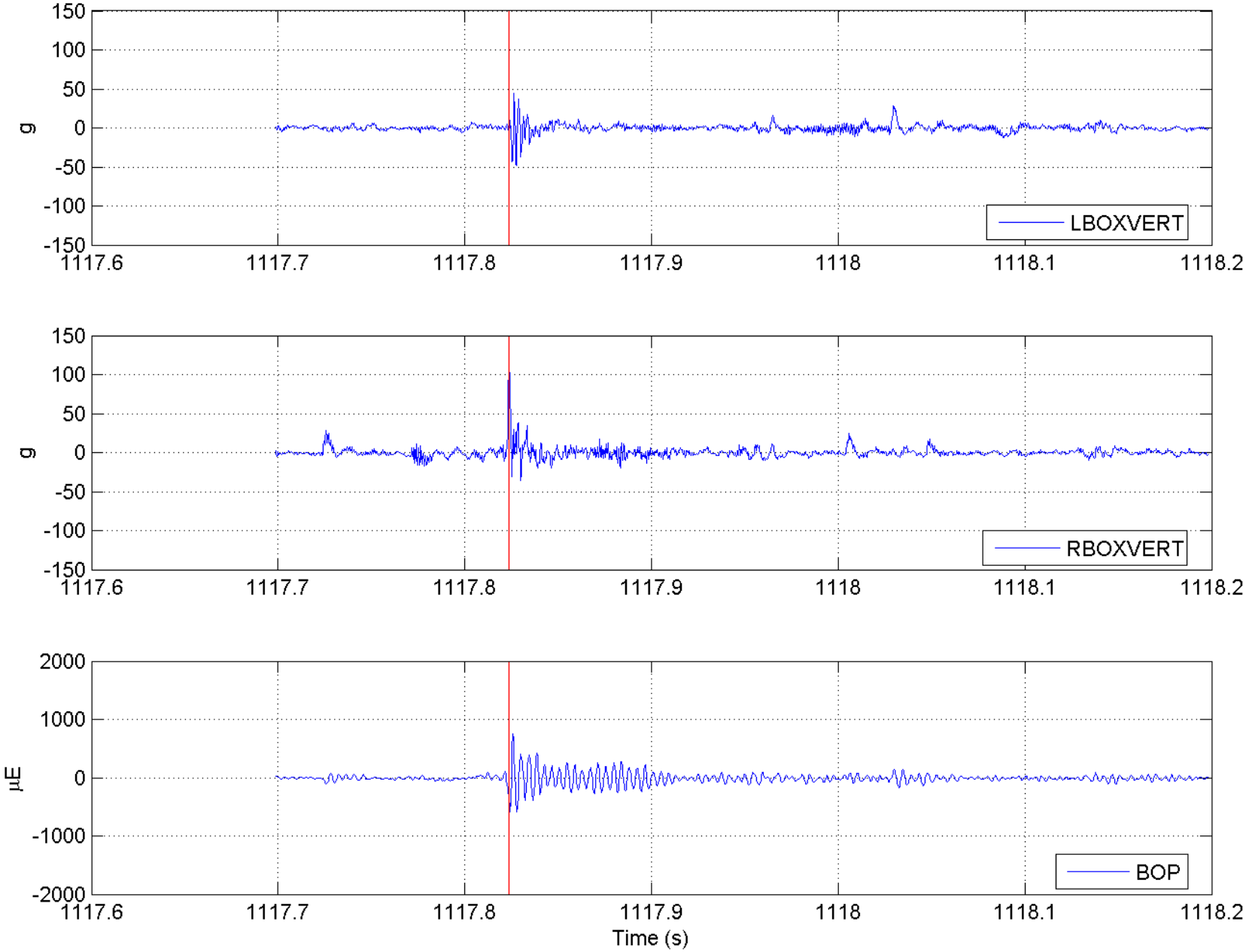
ile 052705_19.AB2, Location 1113.2123 s, LBOXVERT = 39.75 g, RBOXVERT = 120.65 g, BOP = 515.5 uE, Speed = 123.6417 mph, Brake Pressure = 1.58



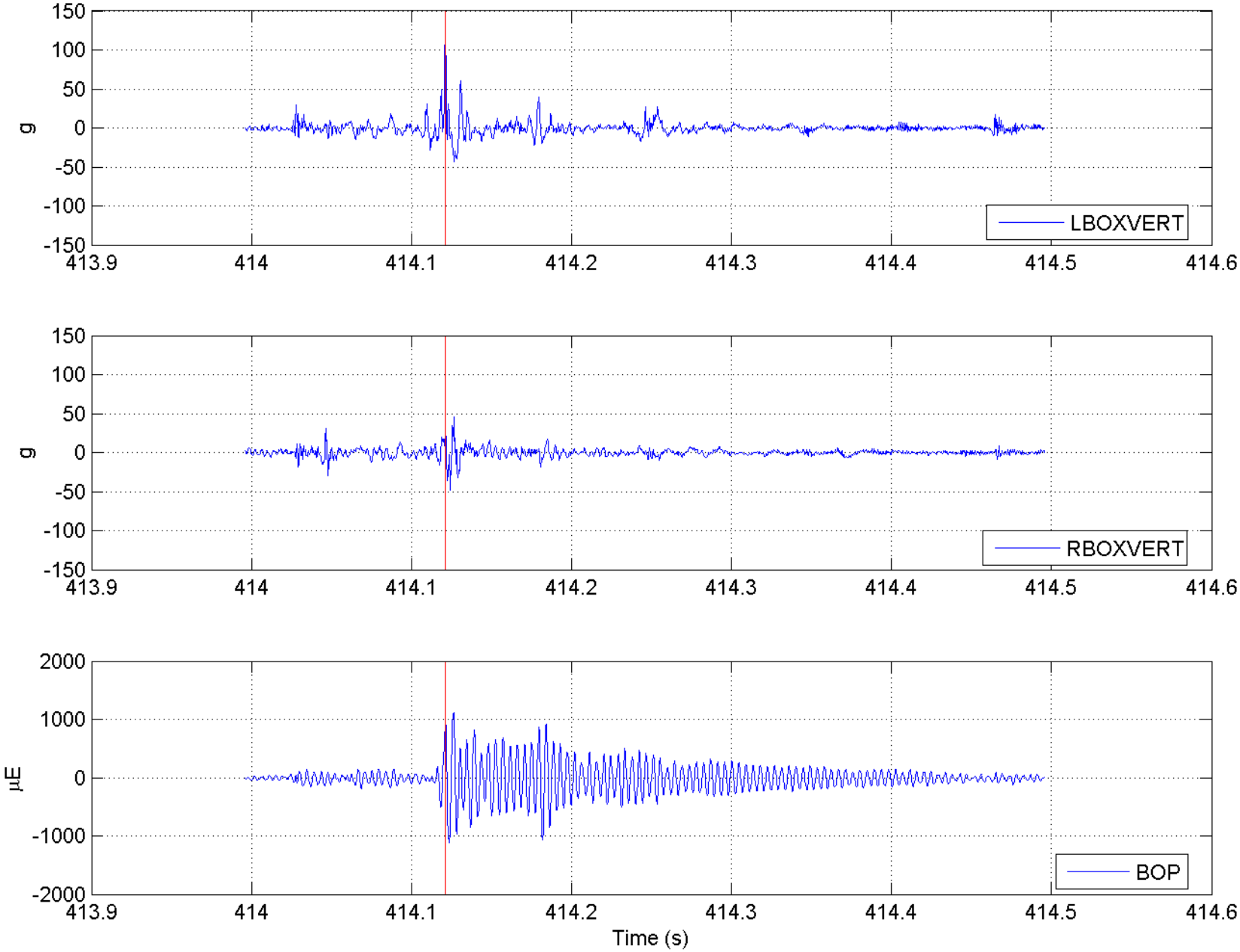
ile 052705_19.AB2, Location 1113.2137 s, LBOXVERT = 39.75 g, RBOXVERT = 120.65 g, BOP = 515.5 uE, Speed = 123.6333 mph, Brake Pressure = 1.58



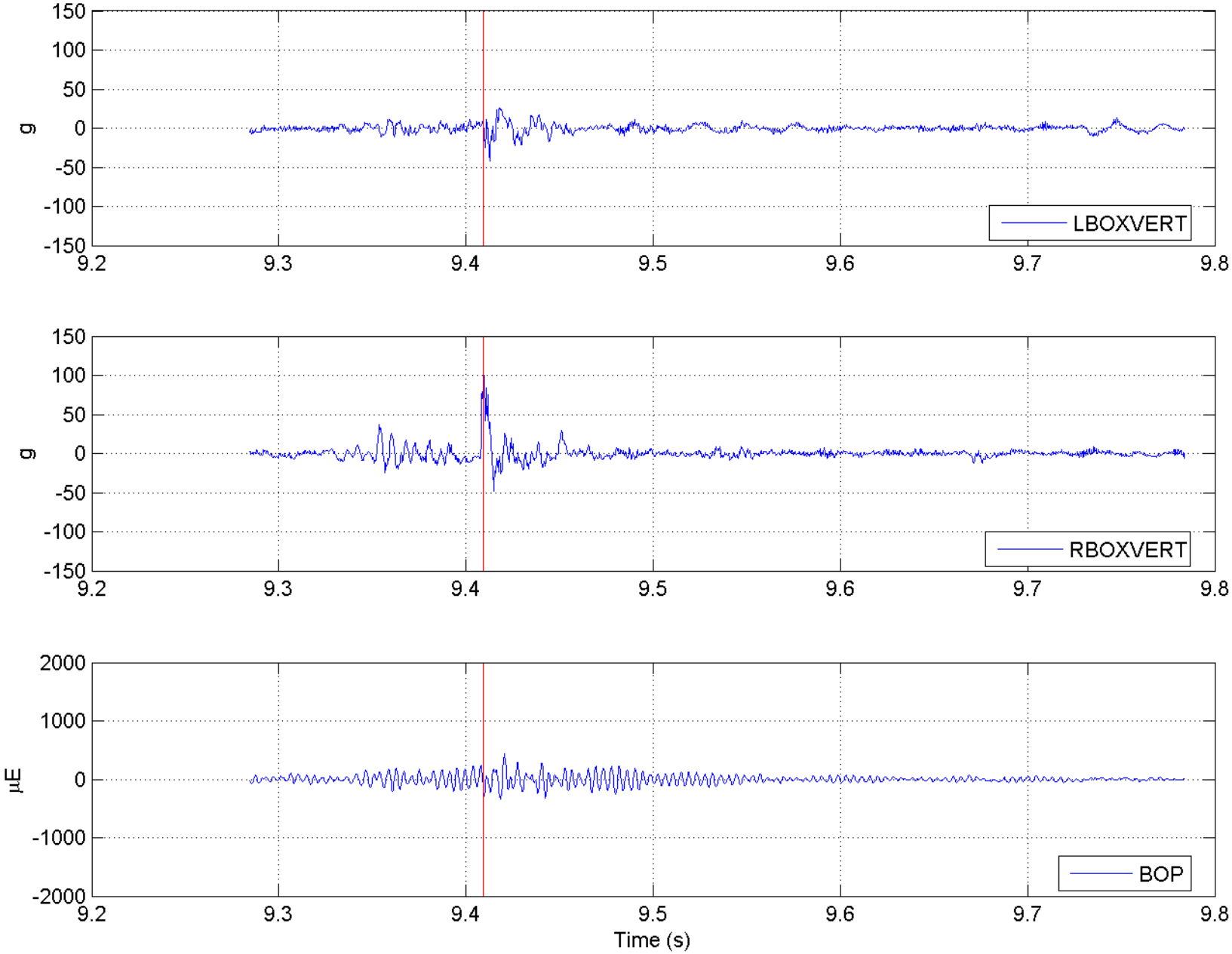
File 052705_19.AB2, Location 1117.8237 s, LBOXVERT = 48.02 g, RBOXVERT = 114.18 g, BOP = 756 uE, Speed = 124.1944 mph, Brake Pressure = 1.58



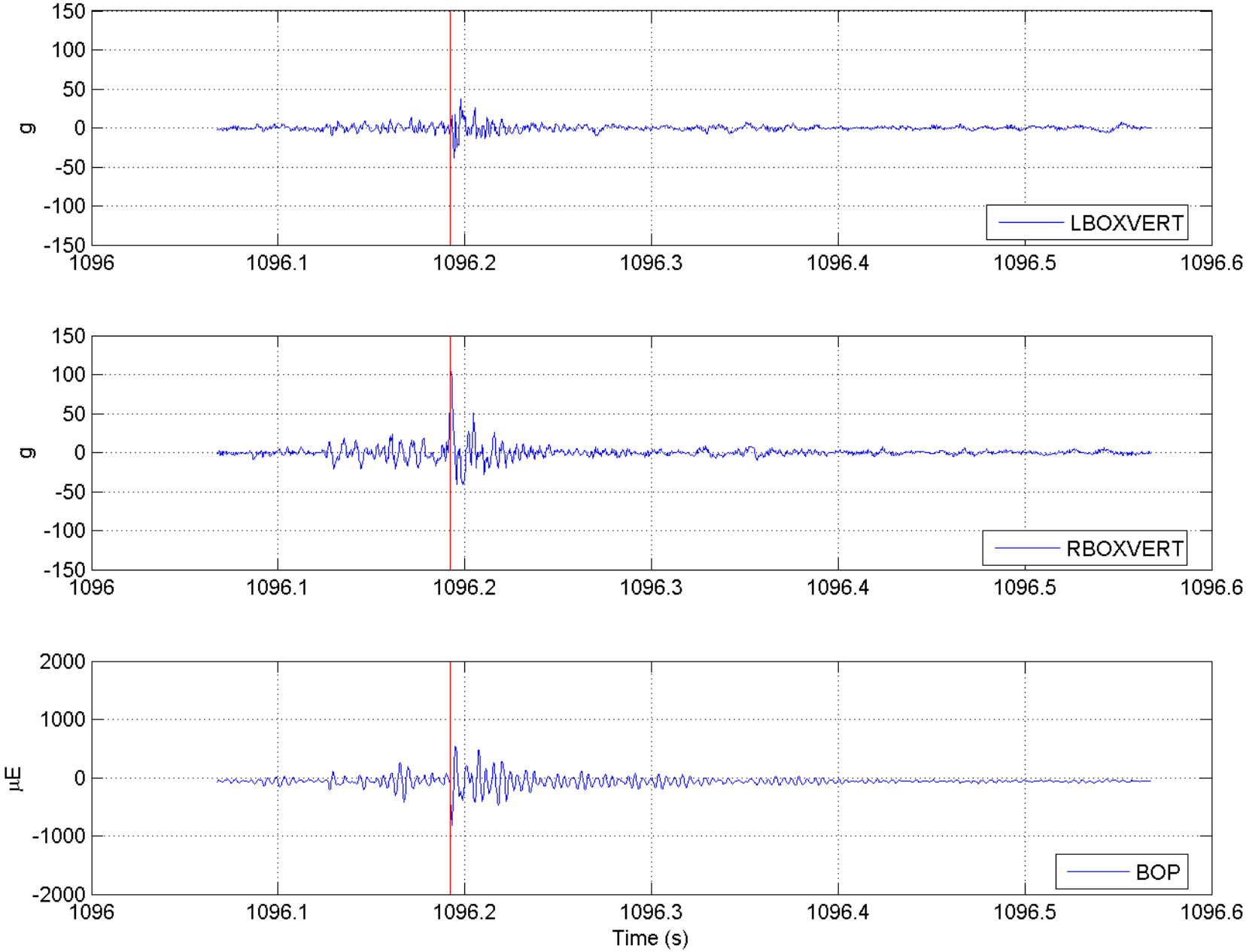
File 052705_20.AB2, Location 414.121 s, LBOXVERT = 123.98 g, RBOXVERT = 47.81 g, BOP = 1113 uE, Speed = 108.7797 mph, Brake Pressure = 1.680



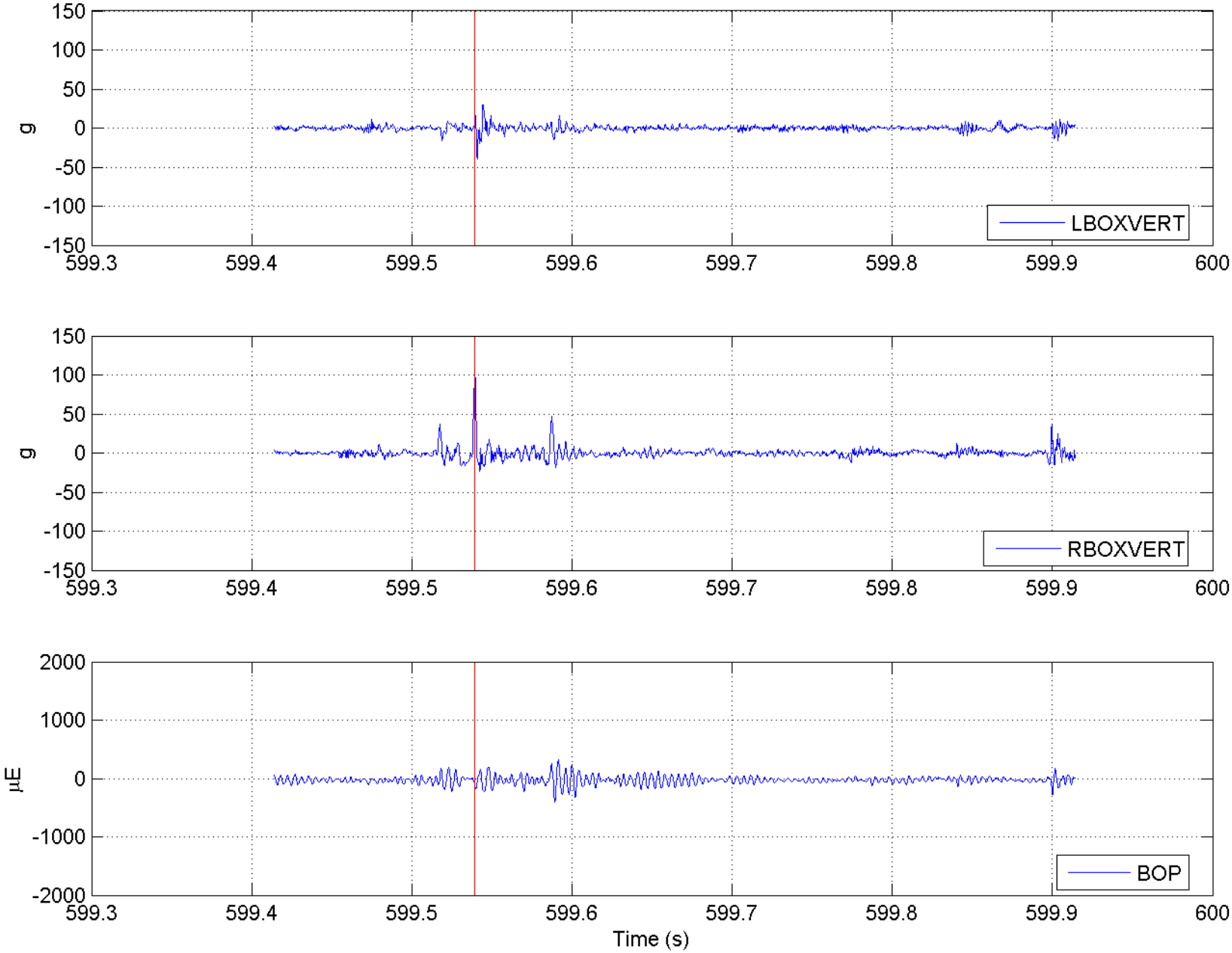
File 052705_20.AB2, Location 9.4093 s, LBOXVERT = 42.28 g, RBOXVERT = 100.63 g, BOP = 441 uE, Speed = 131.6721 mph, Brake Pressure = 1.6059



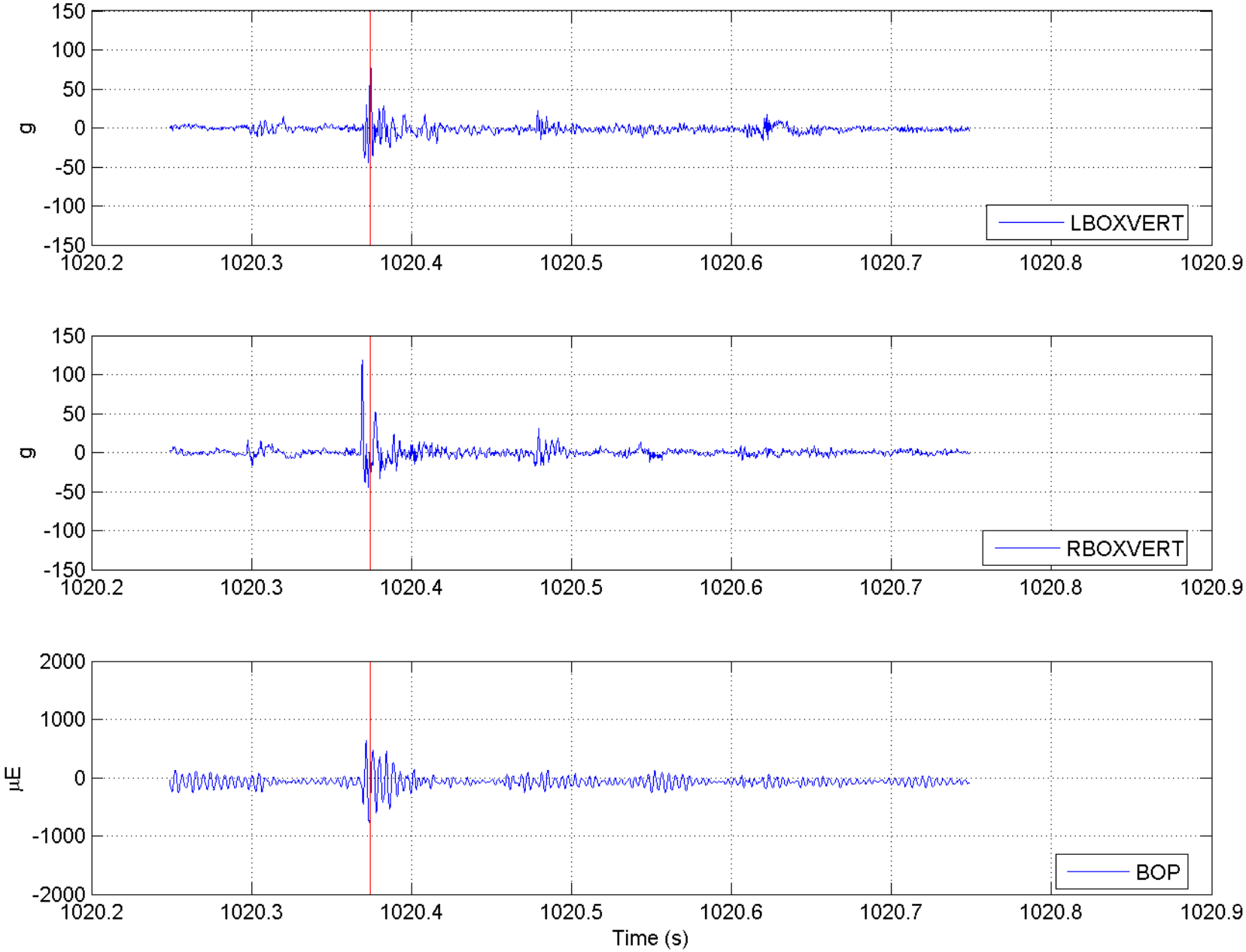
File 052705_20.AB2, Location 1096.1923 s, LBOXVERT = 38.13 g, RBOXVERT = 106.73 g, BOP = 822.5 uE, Speed = 98.3132 mph, Brake Pressure = 1.76



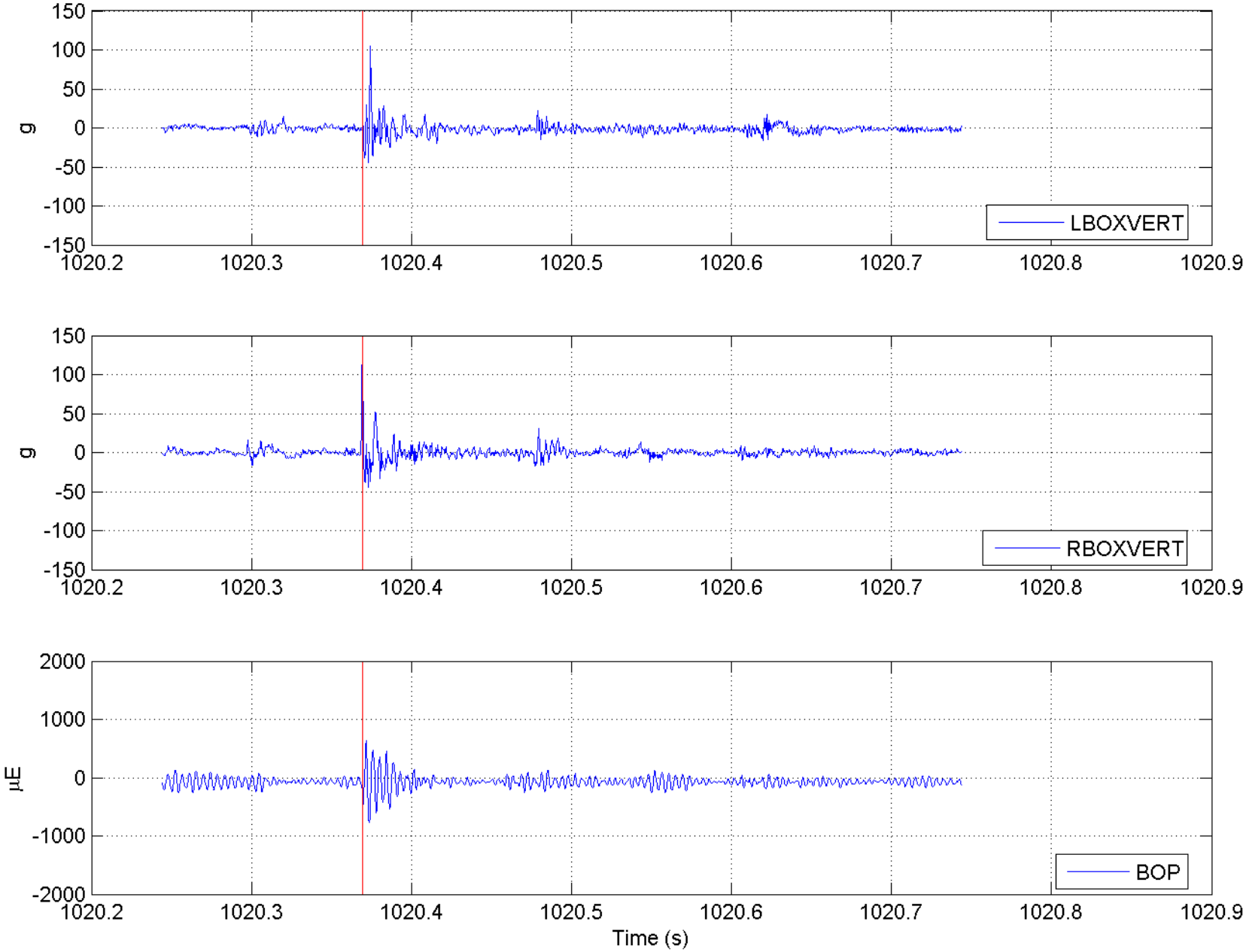
File 052705_22.AB2, Location 599.5393 s, LBOXVERT = 39.11 g, RBOXVERT = 105.63 g, BOP = 413 uE, Speed = 109.7164 mph, Brake Pressure = 2.656



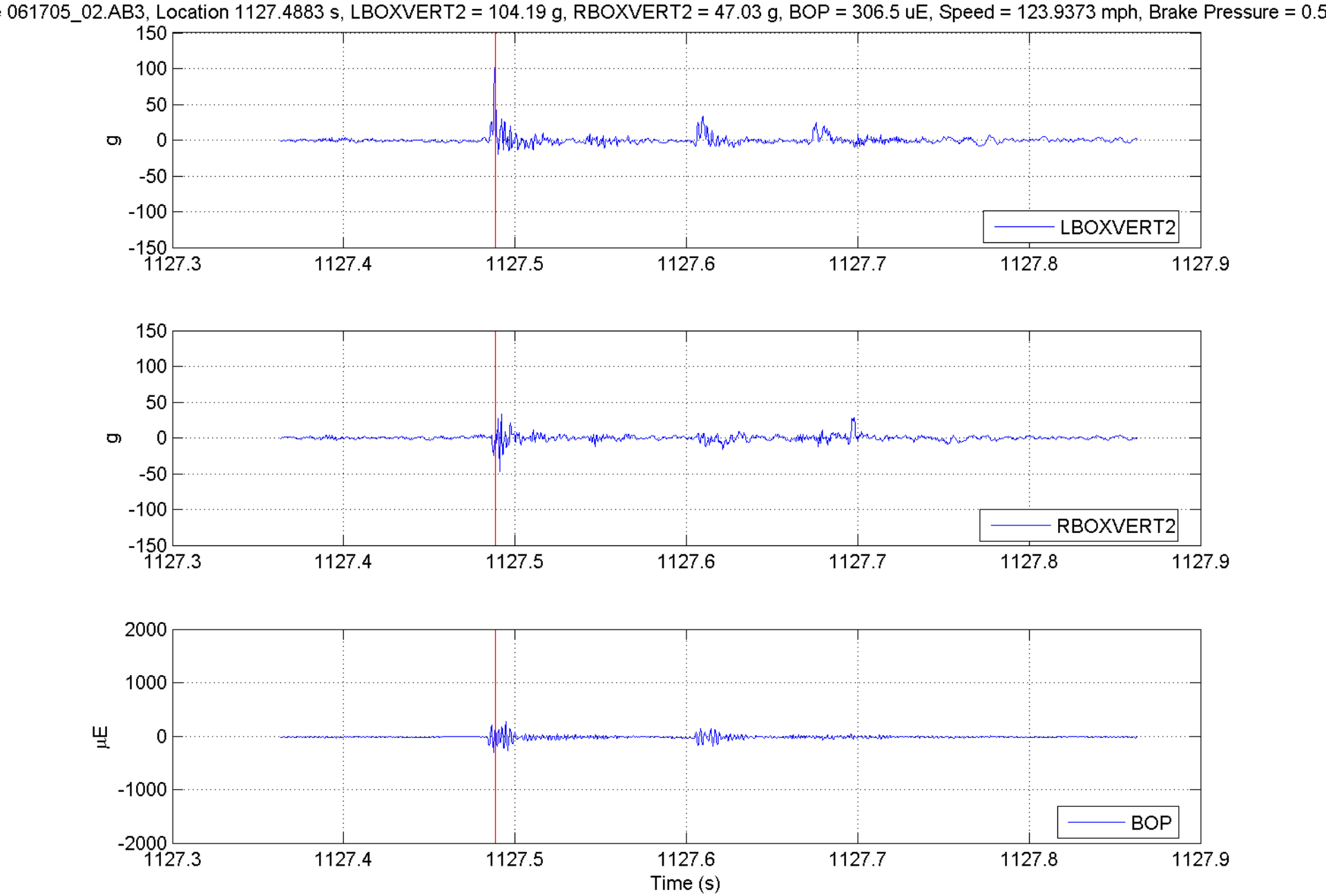
File 052705_23.AB2, Location 1020.374 s, LBOXVERT = 104.45 g, RBOXVERT = 118.21 g, BOP = 776 uE, Speed = 90.3732 mph, Brake Pressure = 2.939



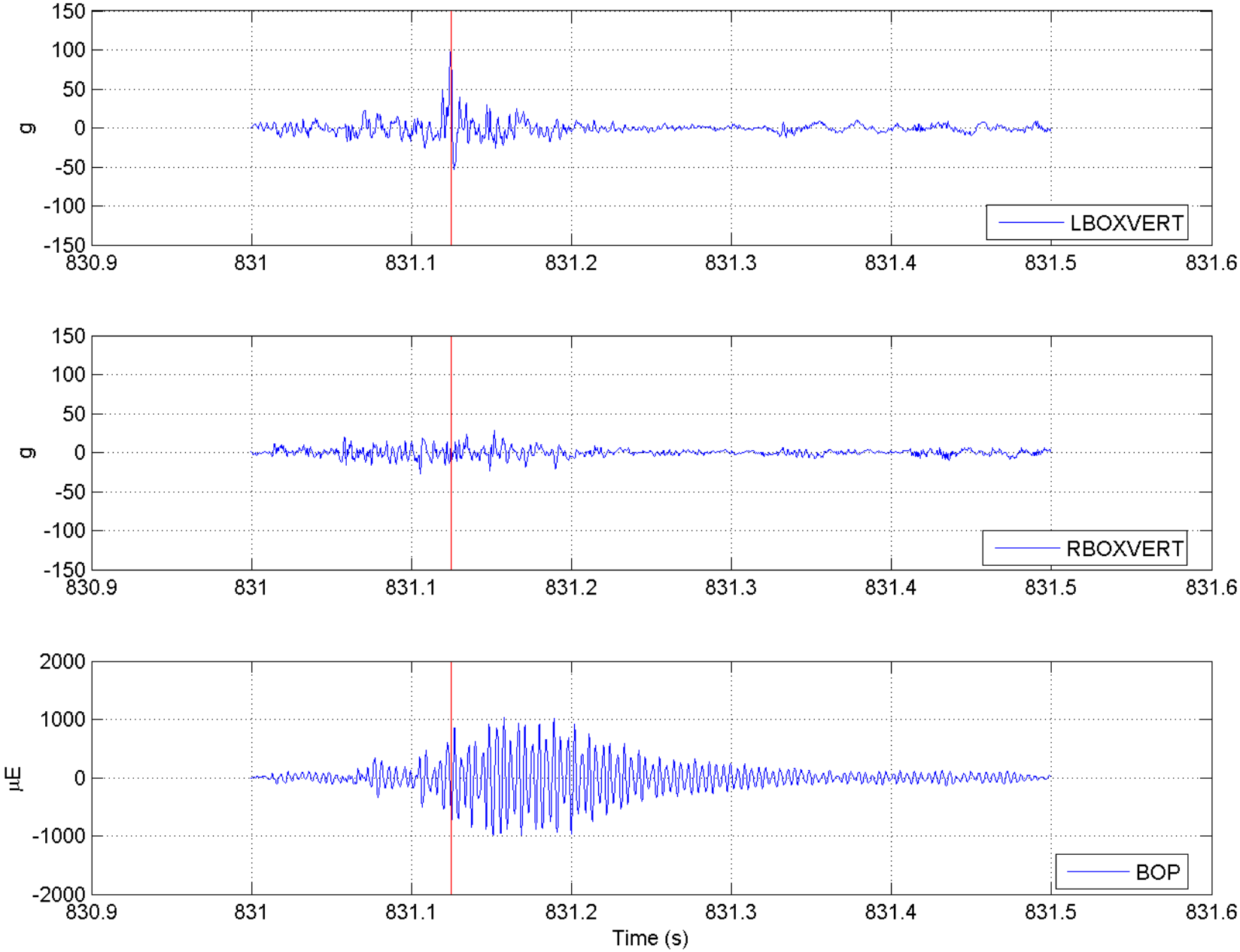
File 052705_23.AB2, Location 1020.3693 s, LBOXVERT = 104.45 g, RBOXVERT = 118.21 g, BOP = 776 uE, Speed = 90.3732 mph, Brake Pressure = 2.93



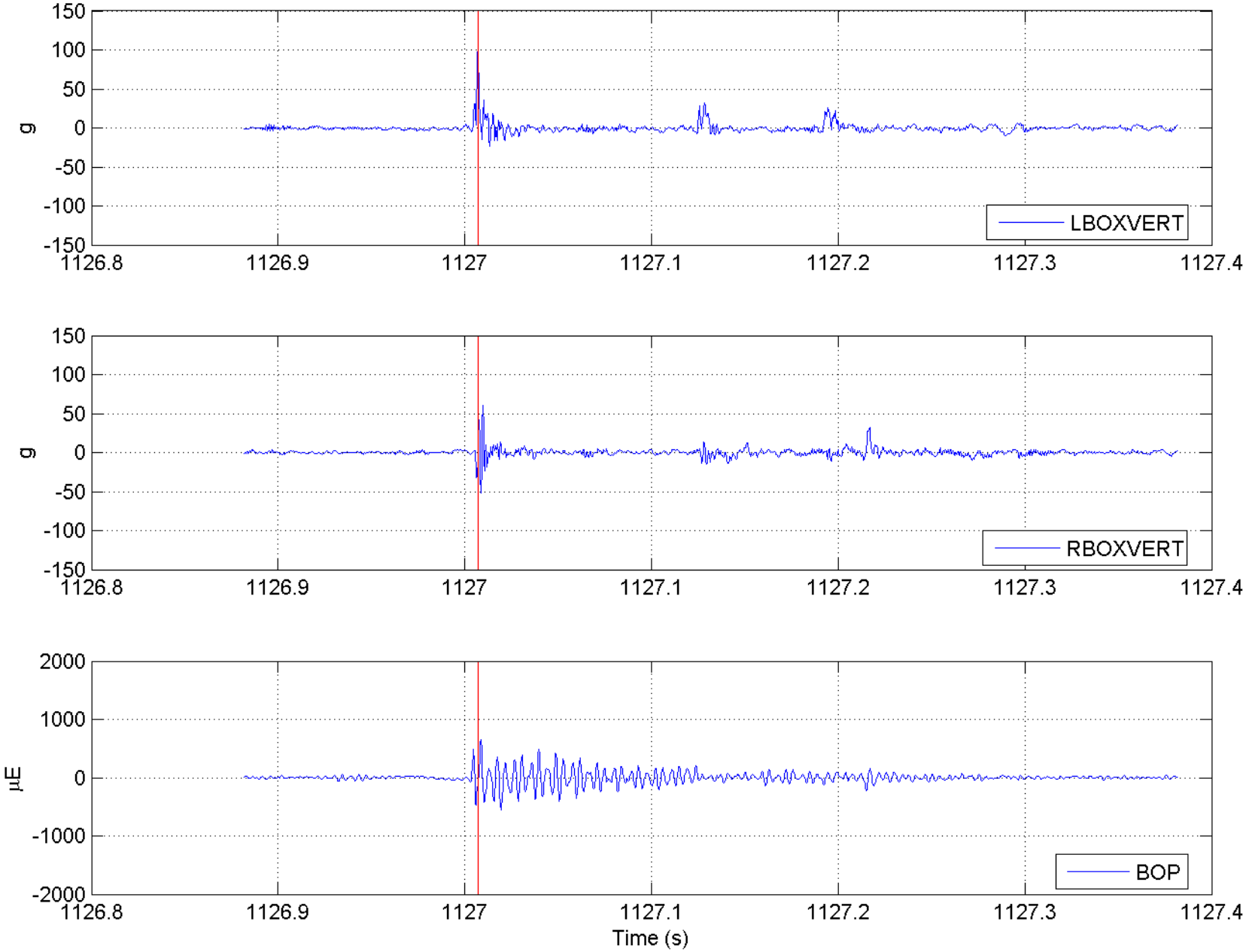
Day 6 – June 17, 2005


061705_02.AB3, Location 1127.4883 s, LBOXVERT2 = 104.19 g, RBOXVERT2 = 47.03 g, BOP = 306.5 uE, Speed = 123.9373 mph, Brake Pressure = 0.5
g
LBOXVERT2
RBOXVERT2
µE
BOP
Time (s)
150
100
50
0
-50
-100
-150
2000
1000
-1000
-2000
1127.3
1127.4
1127.5
1127.6
1127.7
1127.8
1127.9

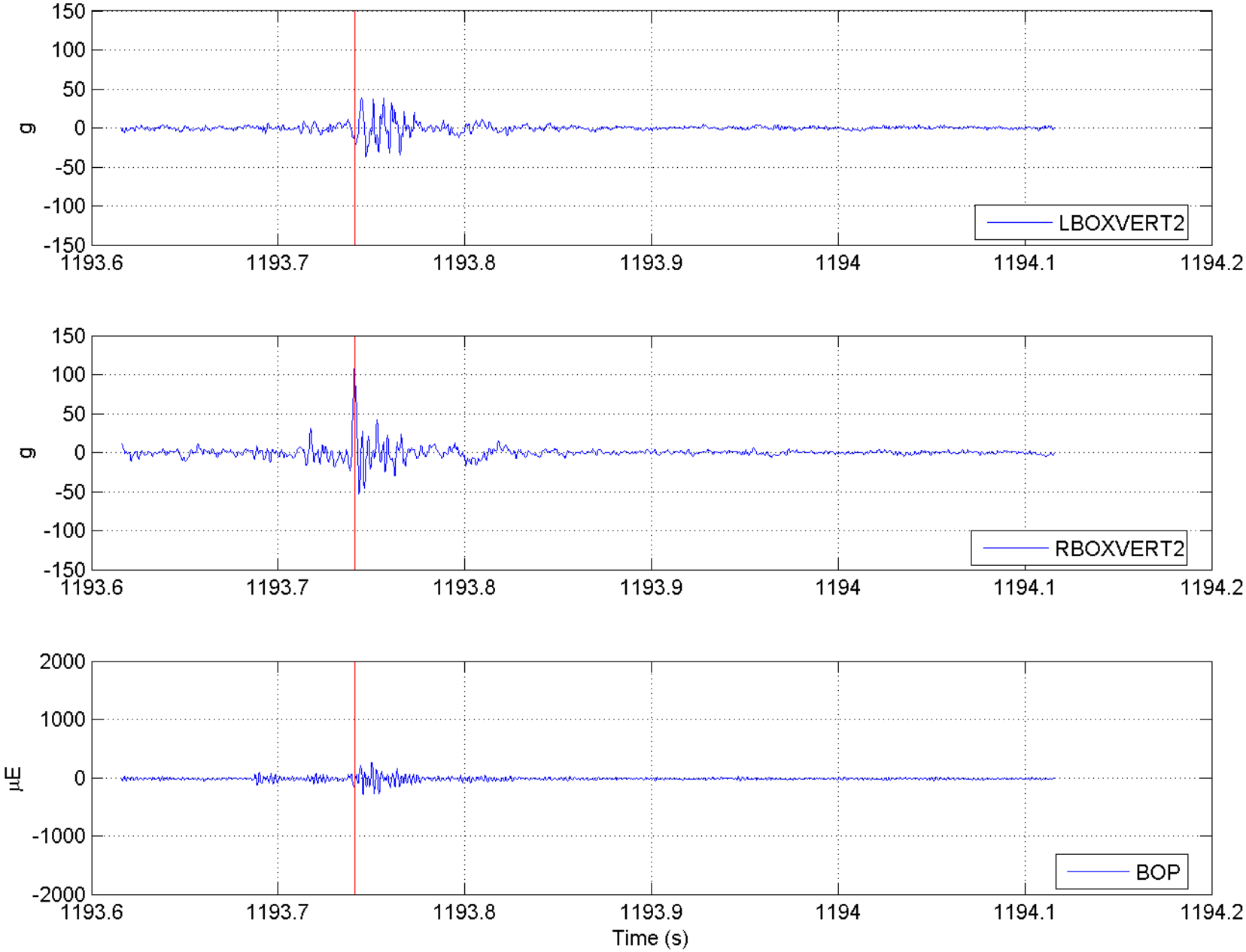
File 061705_02.AB3, Location 831.1247 s, LBOXVERT = 102.67 g, RBOXVERT = 27.95 g, BOP = 1028 uE, Speed = 124.7313 mph, Brake Pressure = 0.451



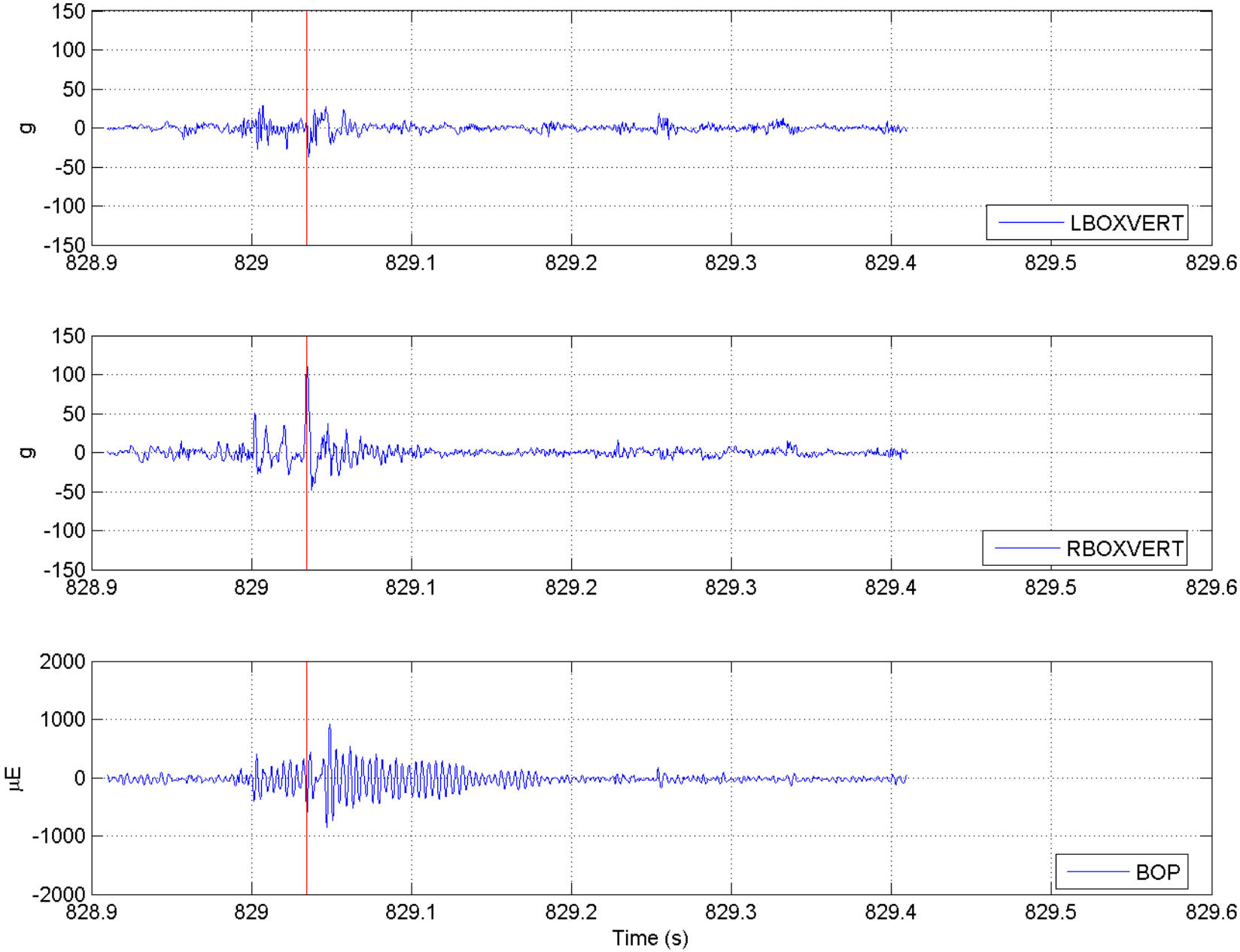
File 061705_02.AB3, Location 1127.007 s, LBOXVERT = 118.49 g, RBOXVERT = 60.63 g, BOP = 651 uE, Speed = 124.0023 mph, Brake Pressure = 0.527



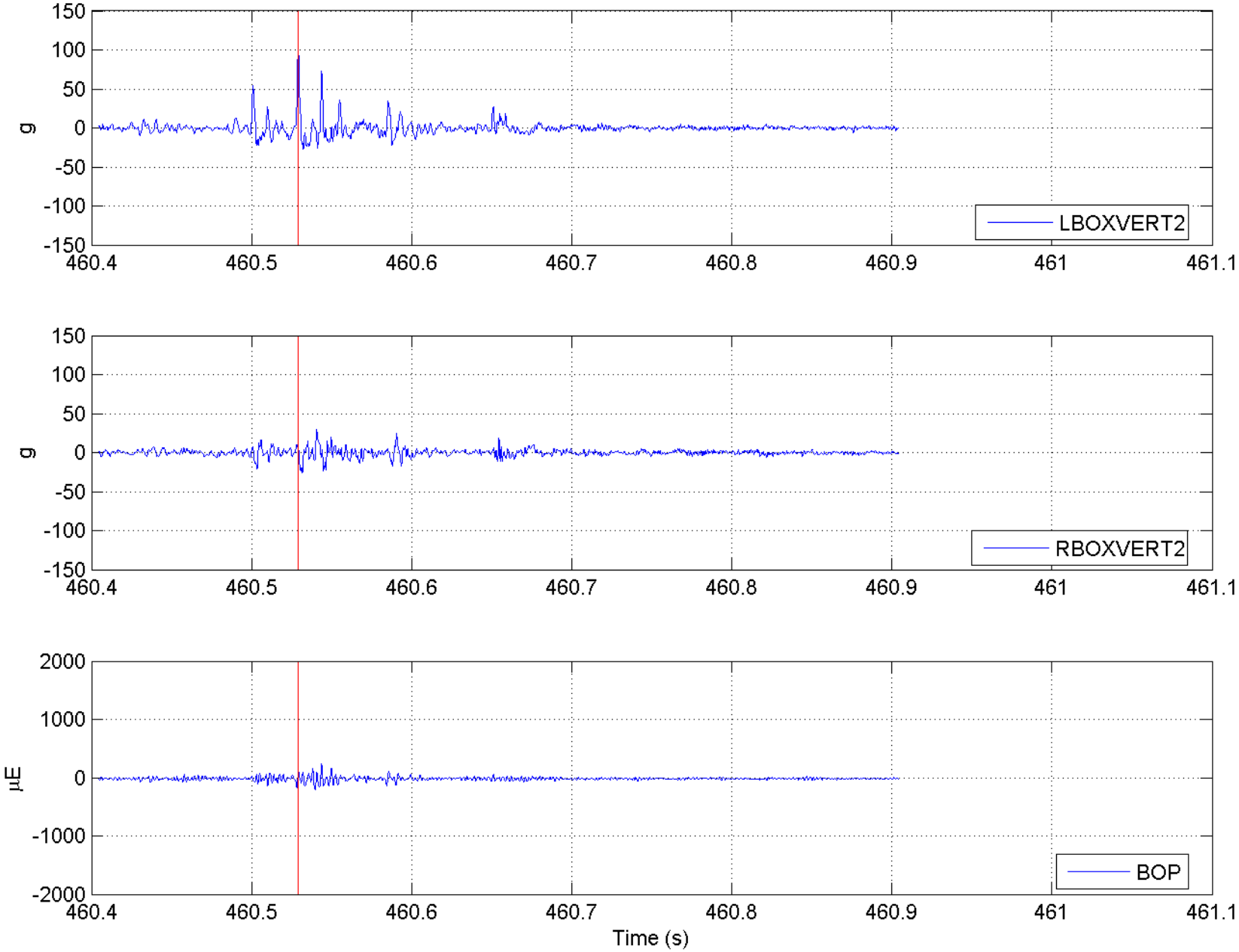
le 061705_06.AB3, Location 1193.741 s, LBOXVERT2 = 38.71 g, RBOXVERT2 = 109.35 g, BOP = 287 uE, Speed = 124.6919 mph, Brake Pressure = 0.44



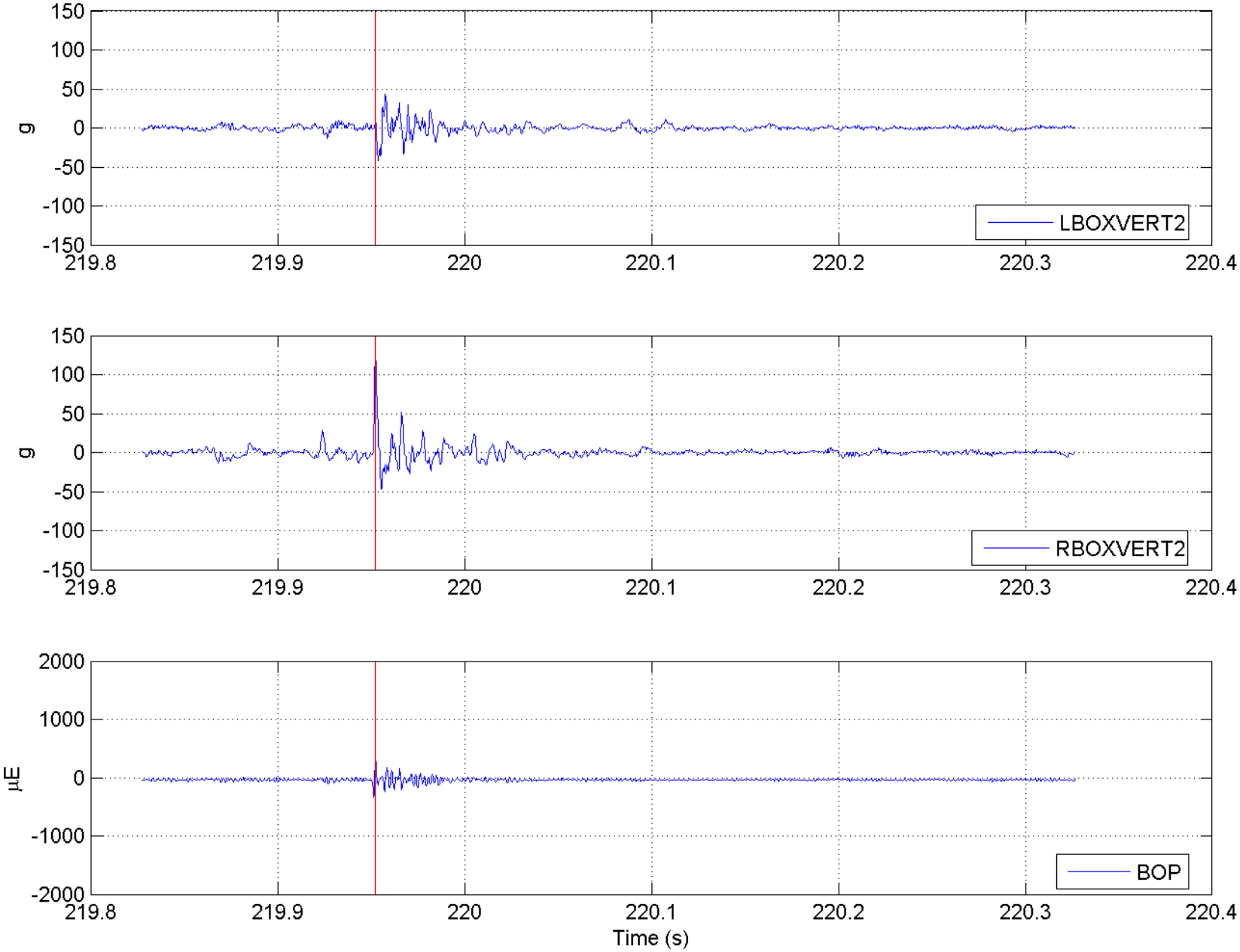
File 061705_06.AB3, Location 829.0347 s, LBOXVERT = 37.63 g, RBOXVERT = 113.32 g, BOP = 920 uE, Speed = 124.6625 mph, Brake Pressure = 0.445



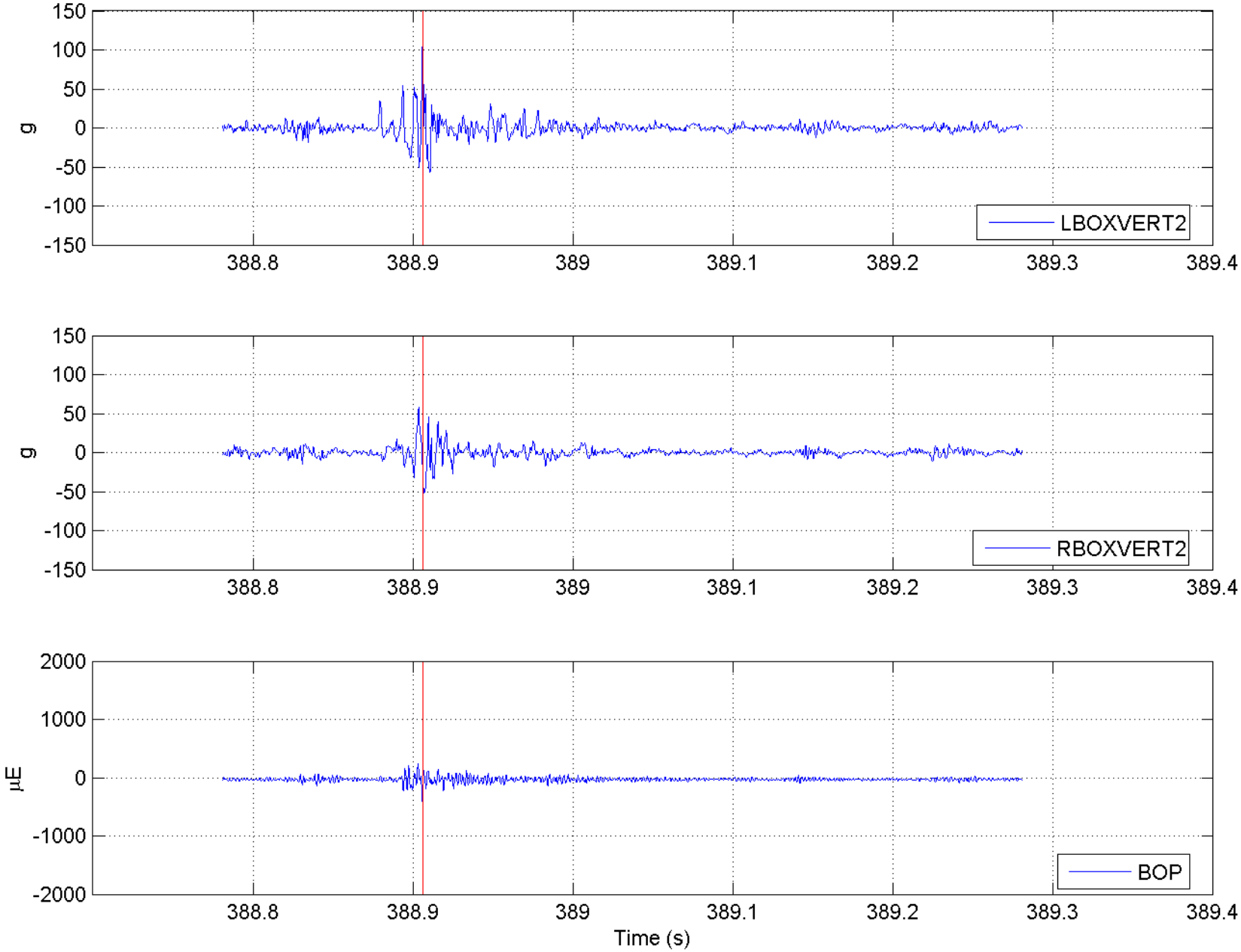
e 061705_07.AB3, Location 460.5293 s, LBOXVERT2 = 105.31 g, RBOXVERT2 = 29.67 g, BOP = 241.5 uE, Speed = 124.0728 mph, Brake Pressure = 0.46



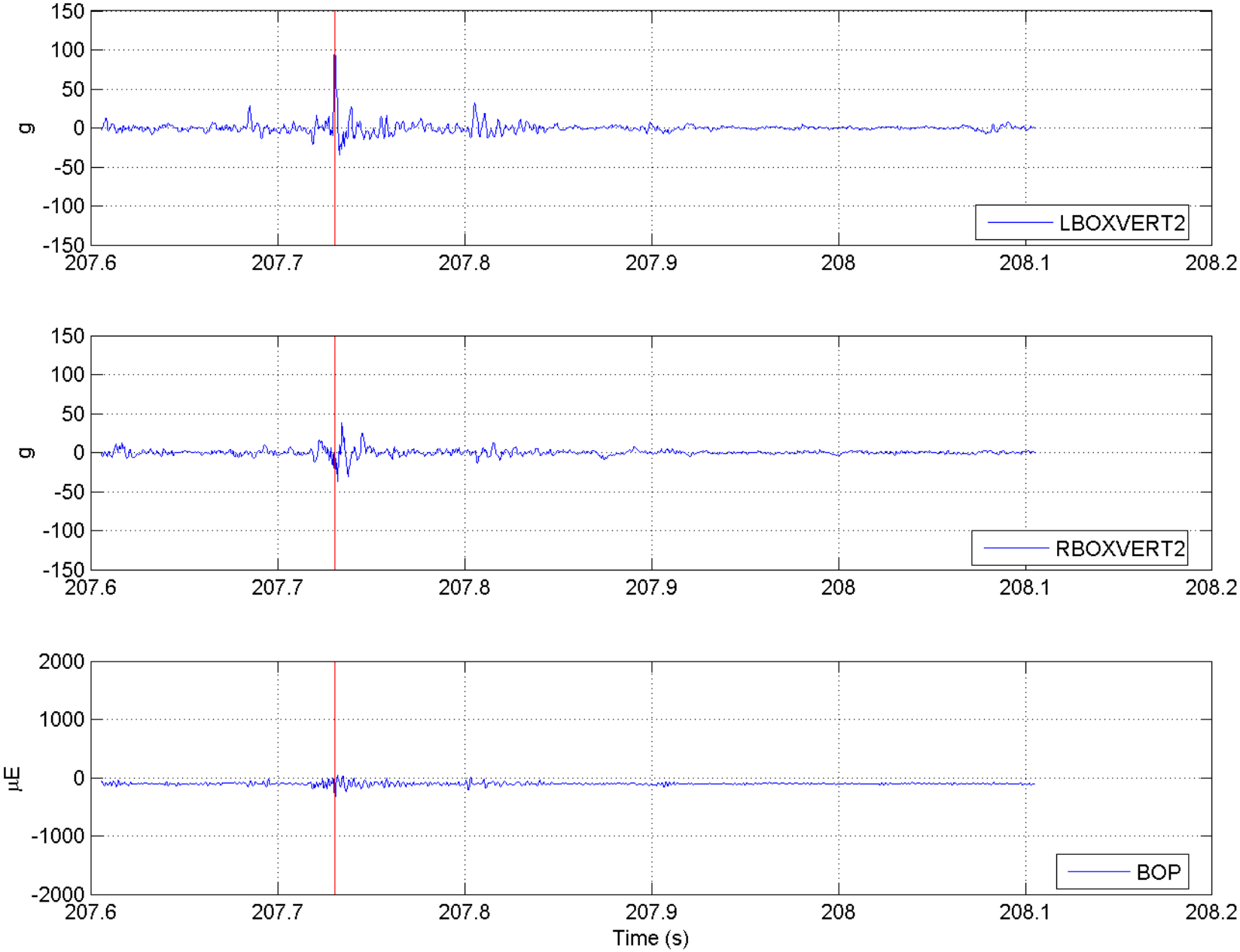
e 061705_07.AB3, Location 219.952 s, LBOXVERT2 = 43.11 g, RBOXVERT2 = 121.61 g, BOP = 340.5 uE, Speed = 133.9254 mph, Brake Pressure = 0.47



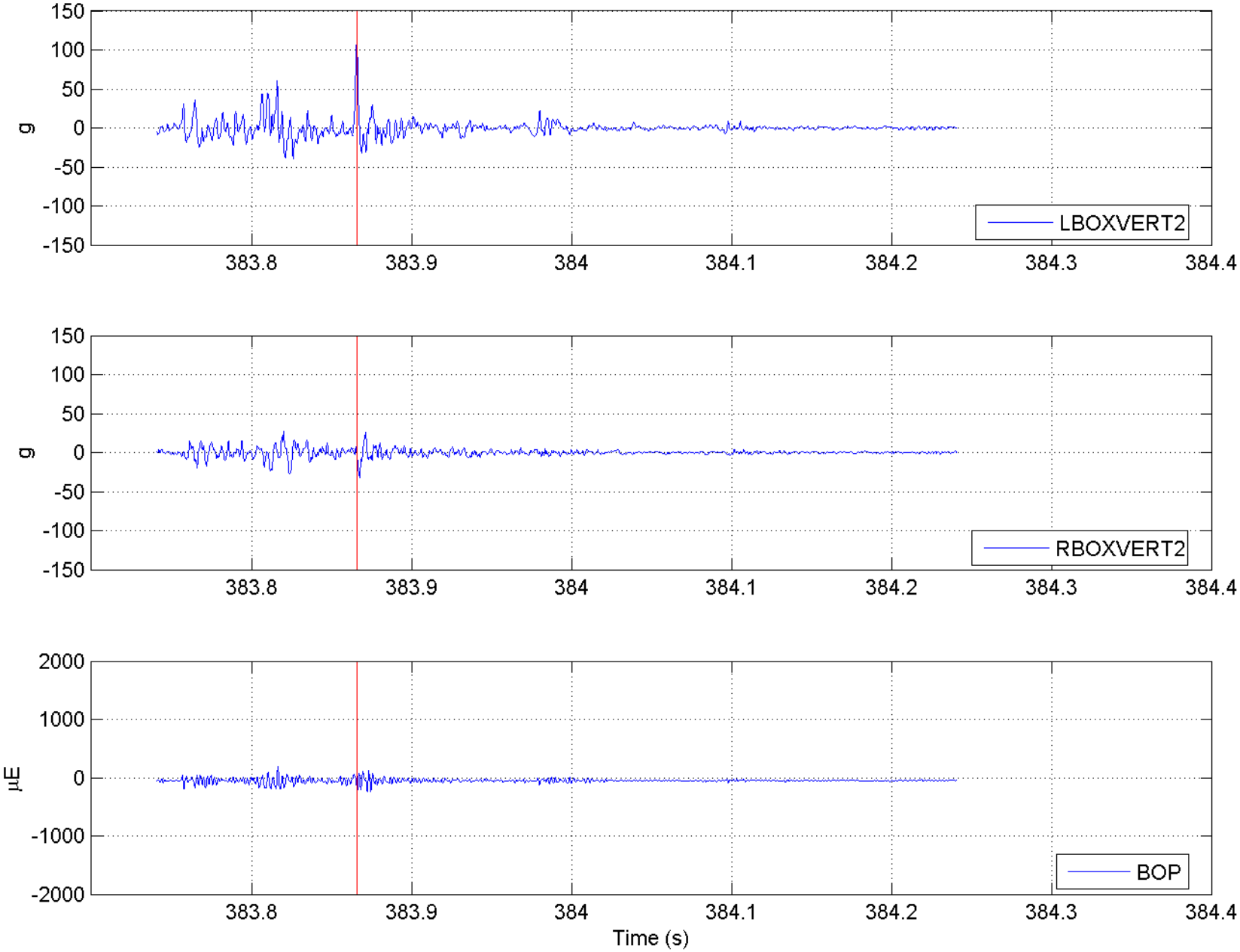
ile 061705_09.AB3, Location 388.906 s, LBOXVERT2 = 120.34 g, RBOXVERT2 = 58.46 g, BOP = 399 uE, Speed = 109.9282 mph, Brake Pressure = 0.440



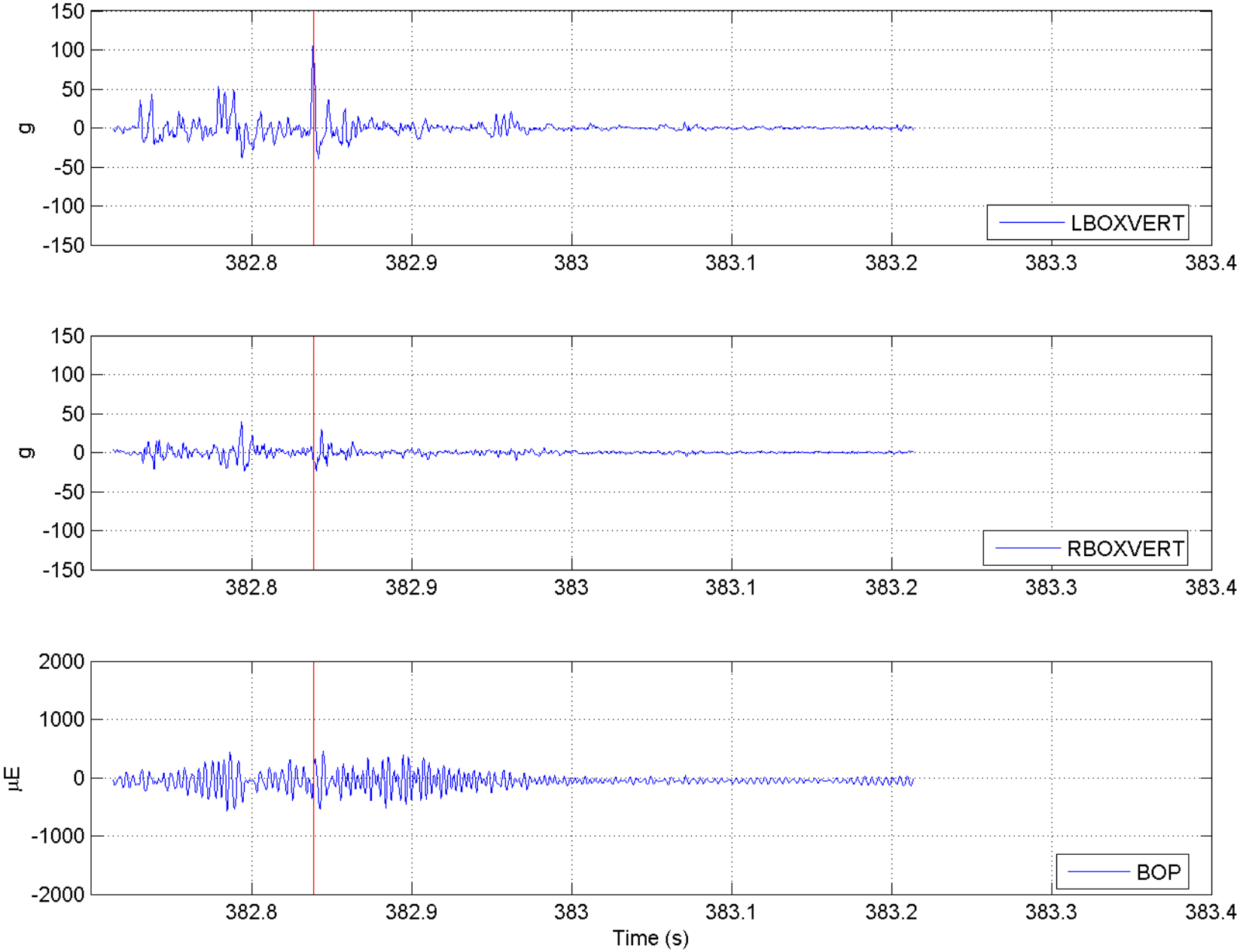
ile 061705_10.AB3, Location 207.7303 s, LBOXVERT2 = 102.71 g, RBOXVERT2 = 38.52 g, BOP = 344 uE, Speed = 84.9046 mph, Brake Pressure = 44.66



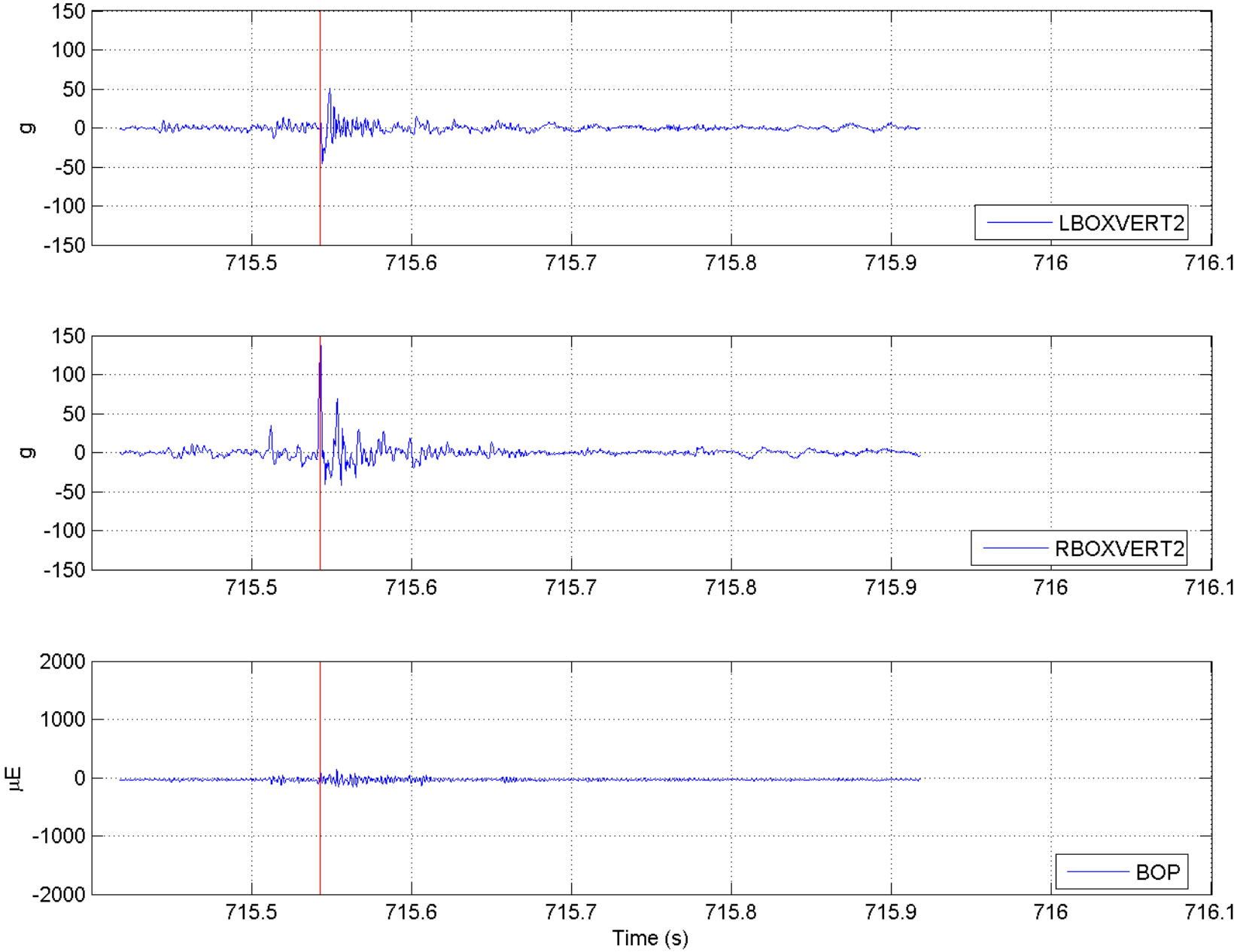
e 061705_11.AB3, Location 383.8657 s, LBOXVERT2 = 112.48 g, RBOXVERT2 = 32.61 g, BOP = 243.5 uE, Speed = 58.0548 mph, Brake Pressure = 0.46



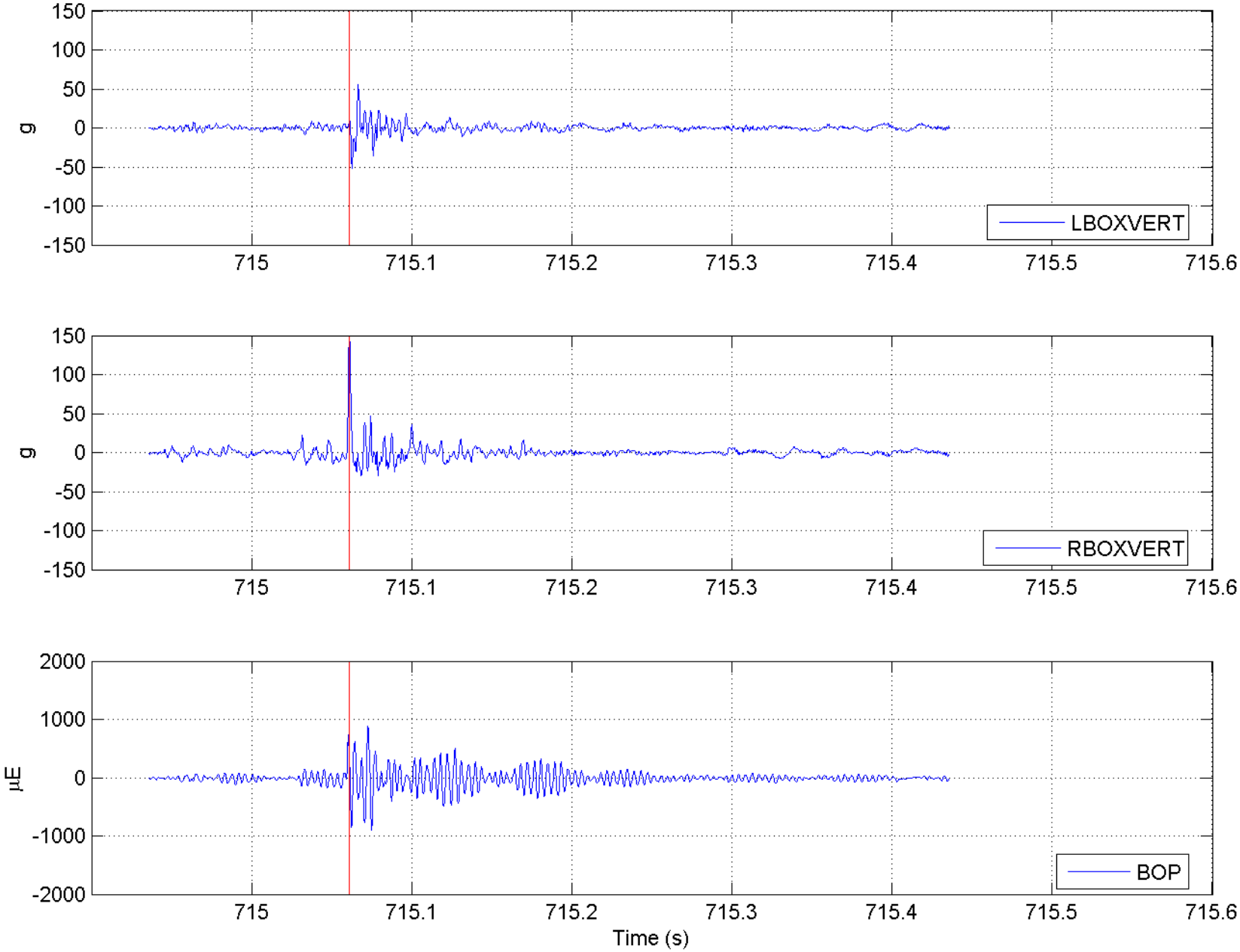
File 061705_11.AB3, Location 382.8387 s, LBOXVERT = 108.37 g, RBOXVERT = 40.1 g, BOP = 562.5 uE, Speed = 58.0268 mph, Brake Pressure = 0.4545



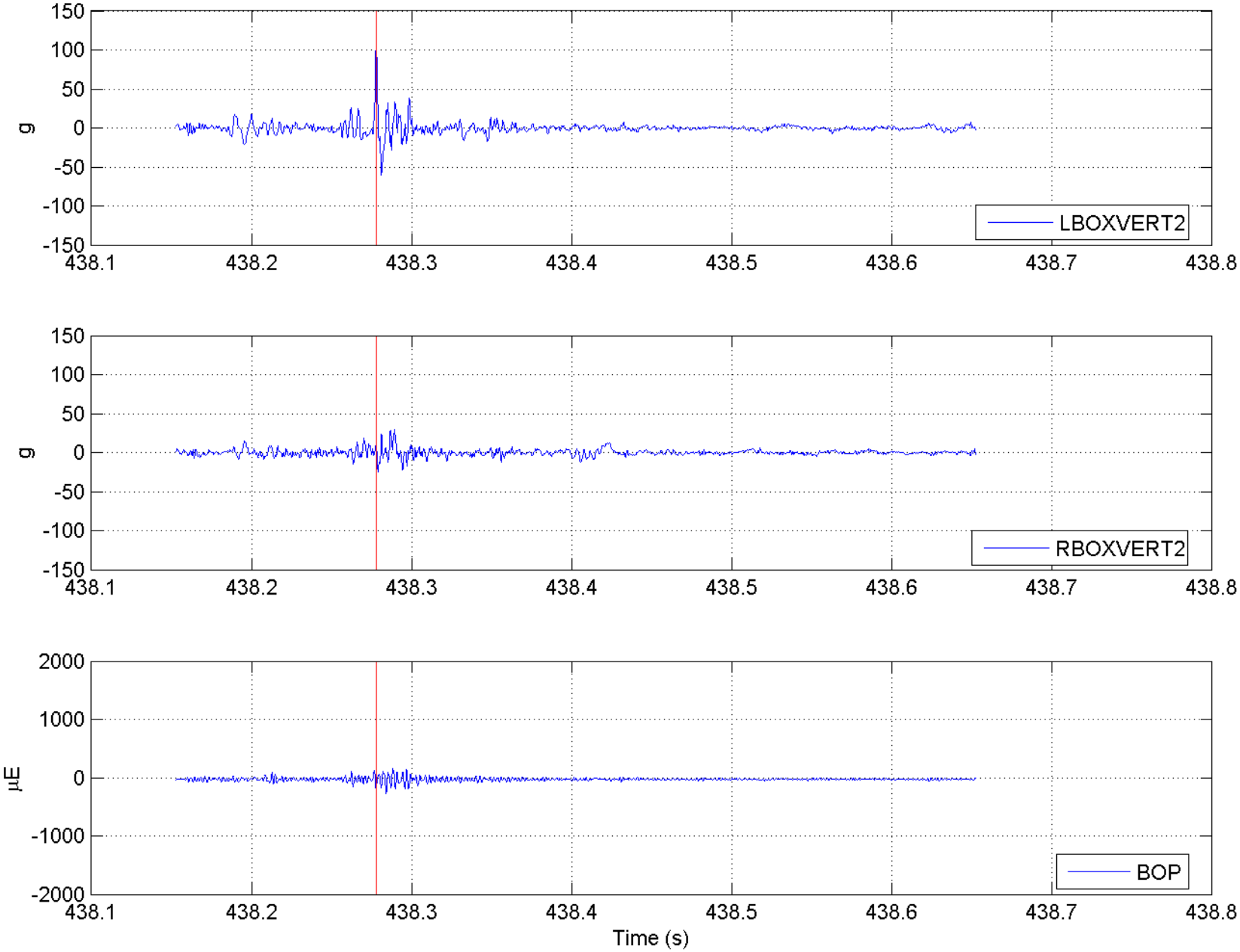
File 061705_11.AB3, Location 715.543 s, LBOXVERT2 = 50.64 g, RBOXVERT2 = 152.25 g, BOP = 158 uE, Speed = 124.0765 mph, Brake Pressure = 0.552

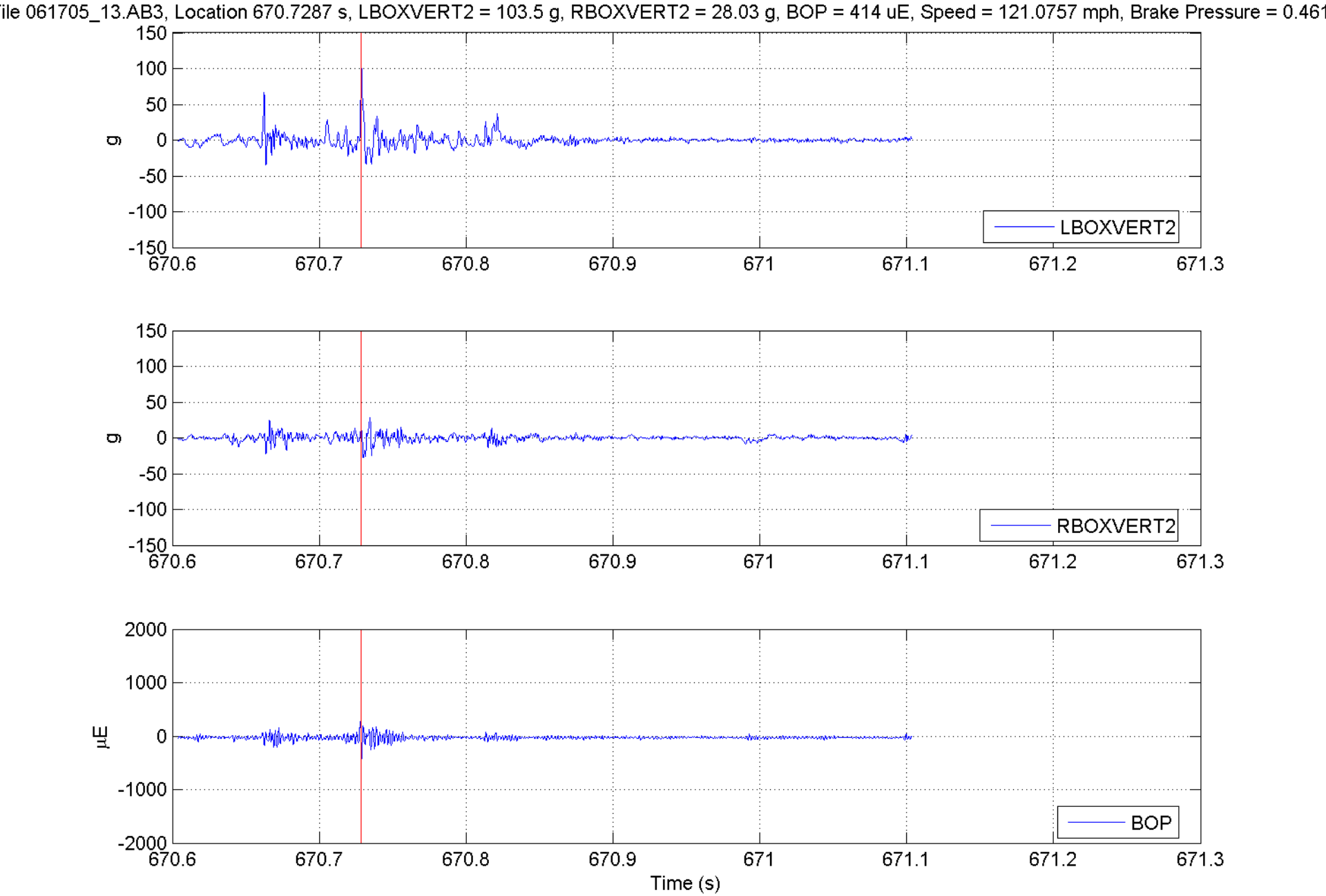


File 061705_11.AB3, Location 715.061 s, LBOXVERT = 55.64 g, RBOXVERT = 150.23 g, BOP = 901.5 uE, Speed = 123.951 mph, Brake Pressure = 0.5683

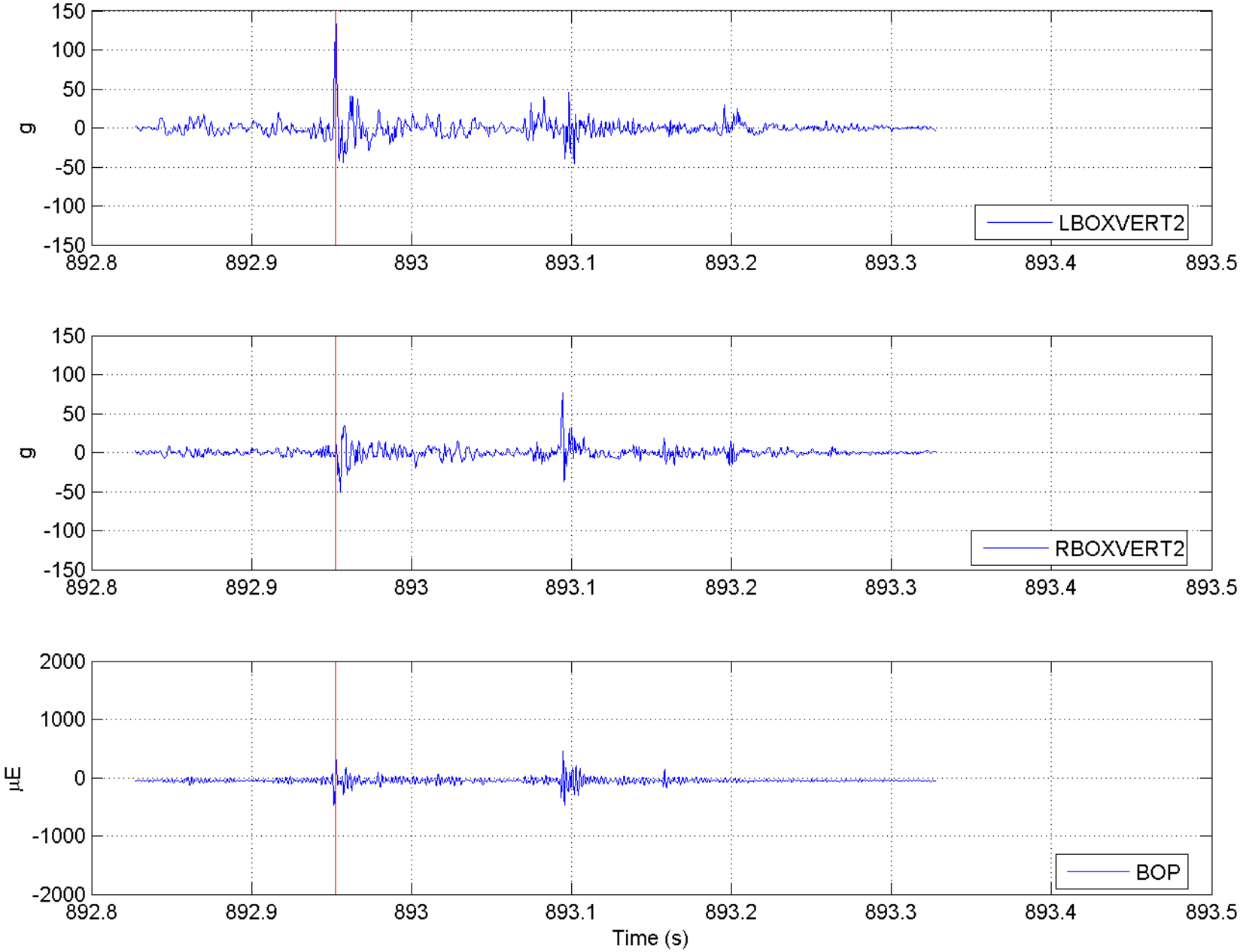


le 061705_13.AB3, Location 438.2777 s, LBOXVERT2 = 112.49 g, RBOXVERT2 = 29.55 g, BOP = 272 uE, Speed = 134.4121 mph, Brake Pressure = 0.52

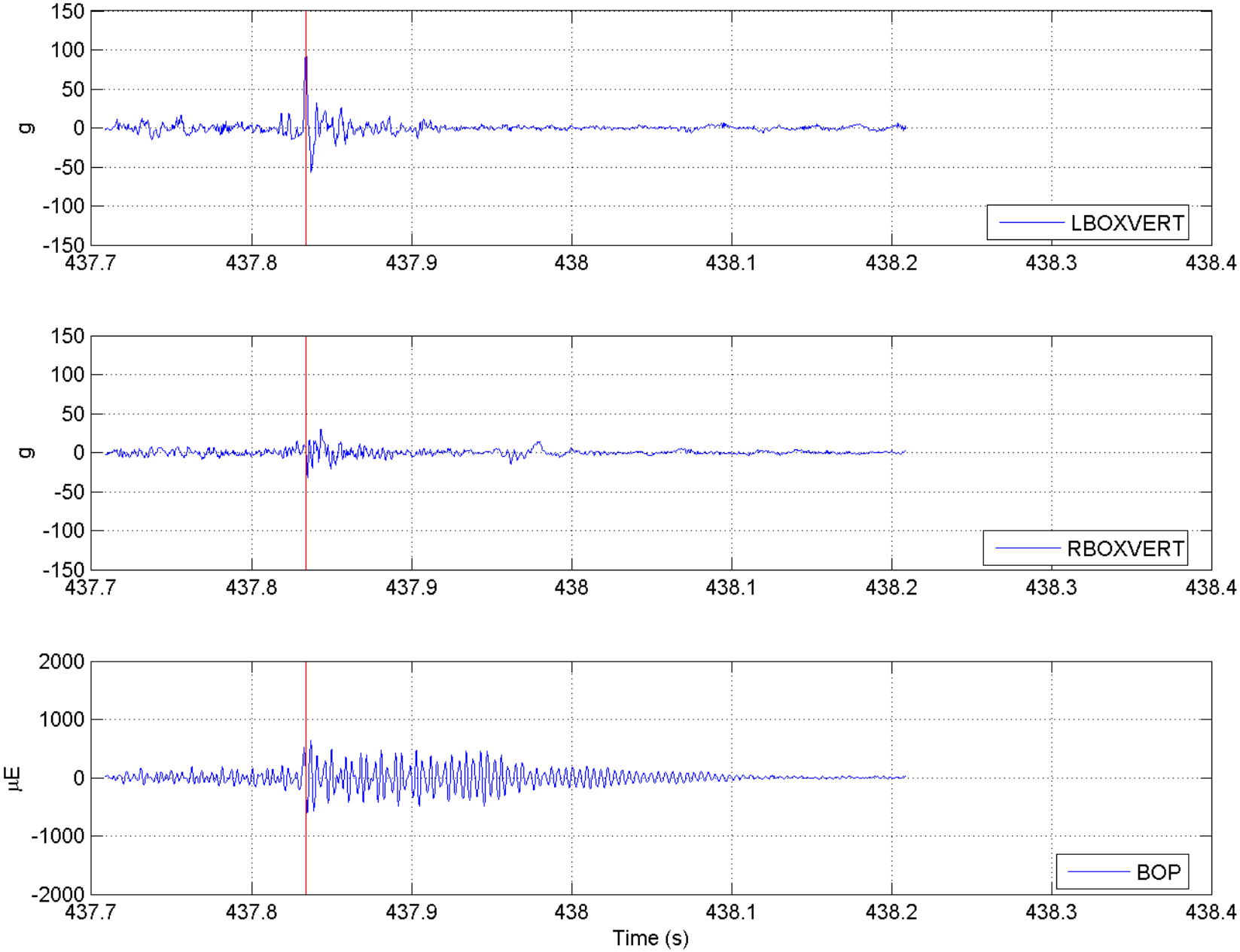



File 061705_13.AB3, Location 670.7287 s, LBOXVERT2 = 103.5 g, RBOXVERT2 = 28.03 g, BOP = 414 uE, Speed = 121.0757 mph, Brake Pressure = 0.461
g
LBOXVERT2
RBOXVERT2
µE
BOP
Time (s)
150
100
50
0
-50
-100
-150
2000
1000
-1000
-2000
670.6
670.7
670.8
670.9
671
671.1
671.2
671.3

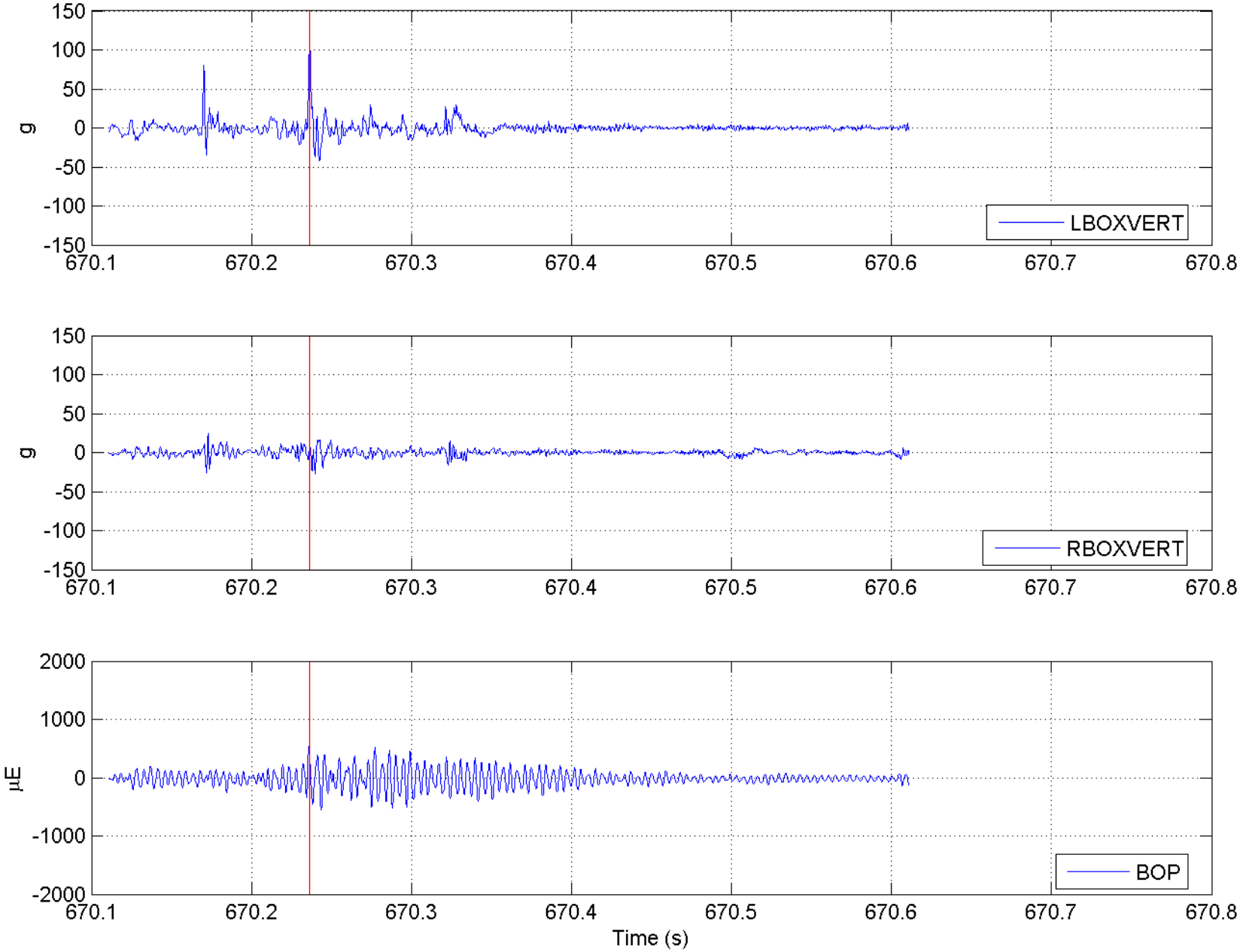
le 061705_13.AB3, Location 892.9527 s, LBOXVERT2 = 149.31 g, RBOXVERT2 = 76.21 g, BOP = 475 uE, Speed = 109.2439 mph, Brake Pressure = 0.45



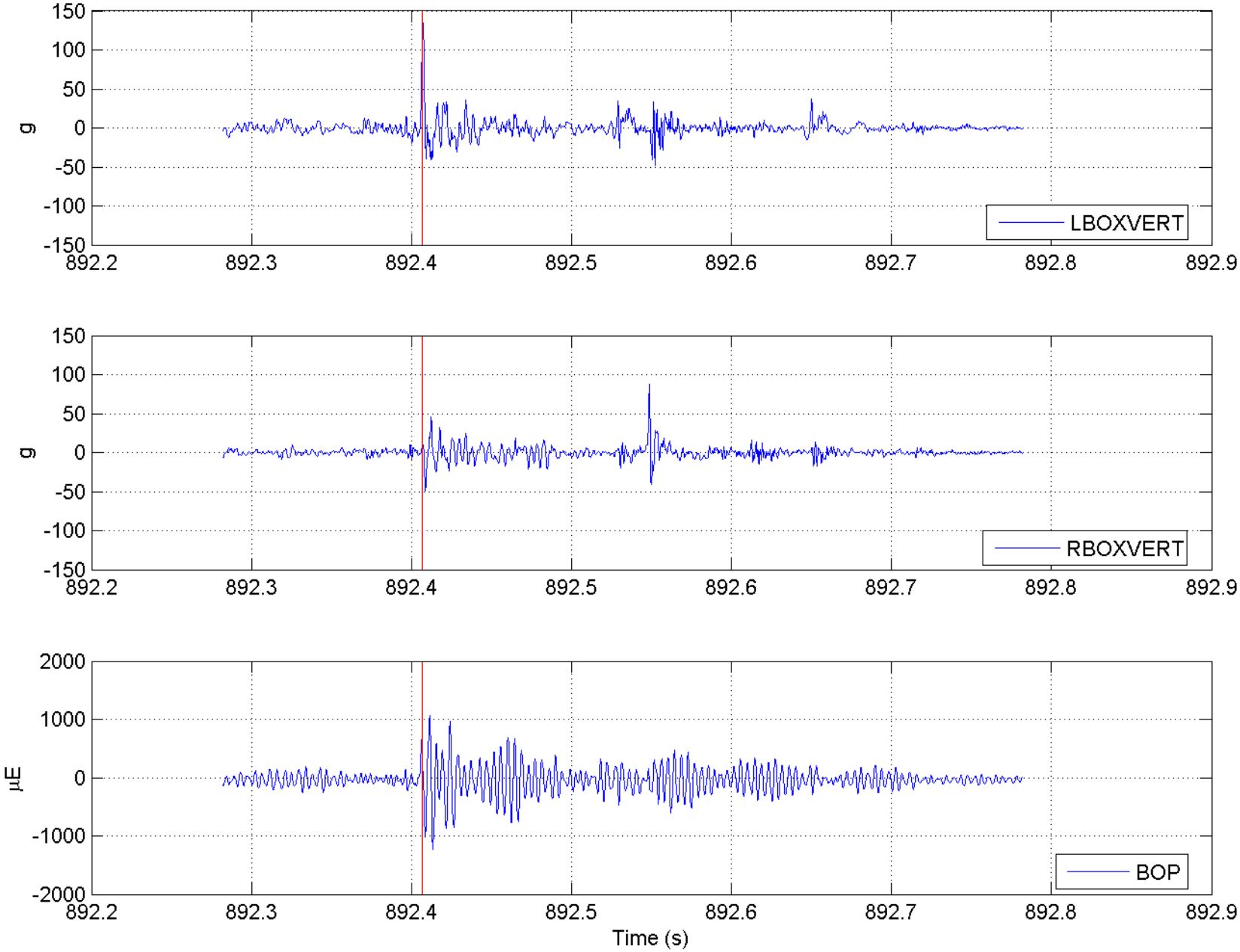
File 061705_13.AB3, Location 437.8337 s, LBOXVERT = 103.3 g, RBOXVERT = 31.73 g, BOP = 630.5 uE, Speed = 134.3397 mph, Brake Pressure = 0.530



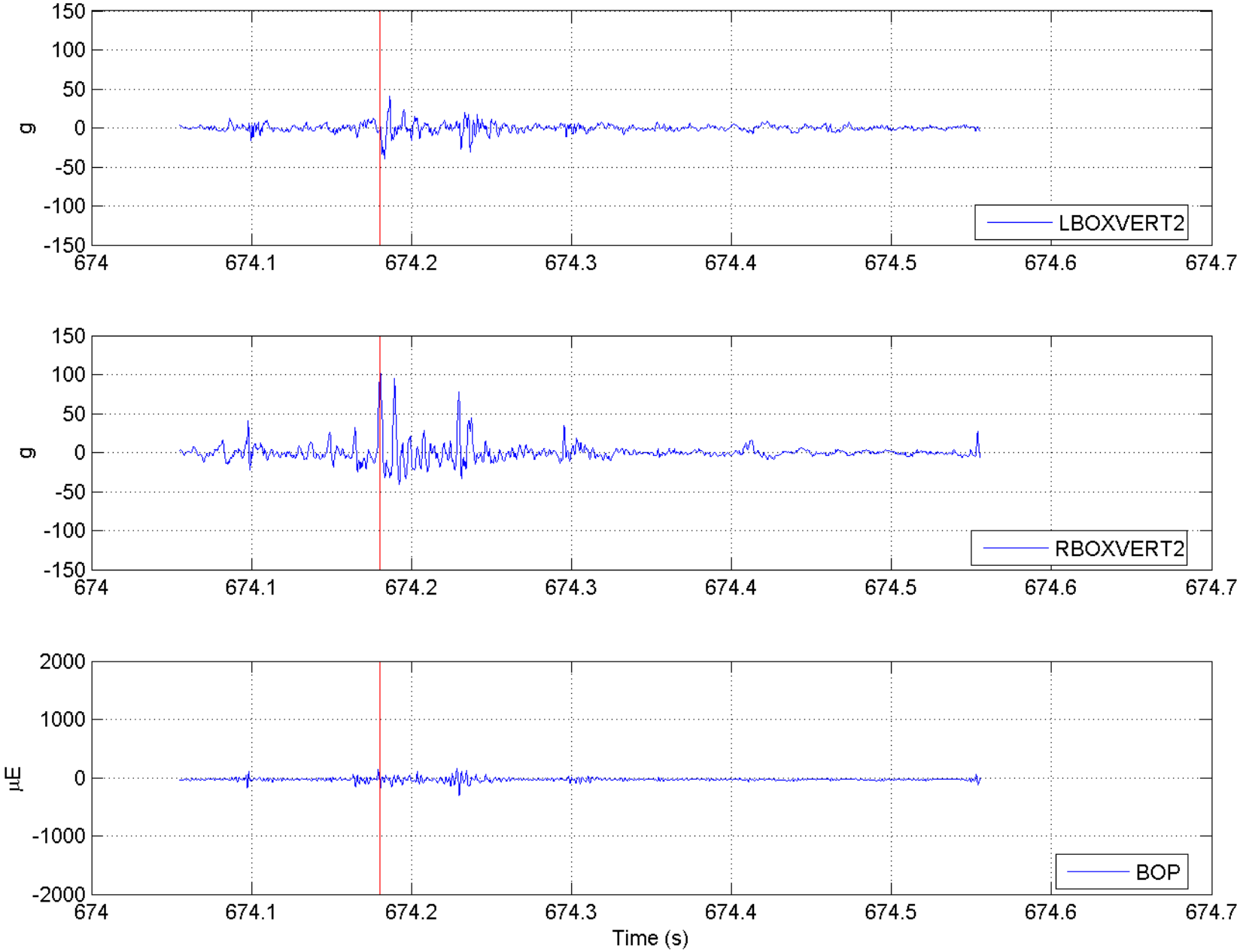
File 061705_13.AB3, Location 670.2363 s, LBOXVERT = 104.63 g, RBOXVERT = 27.72 g, BOP = 555 uE, Speed = 121.2014 mph, Brake Pressure = 0.463



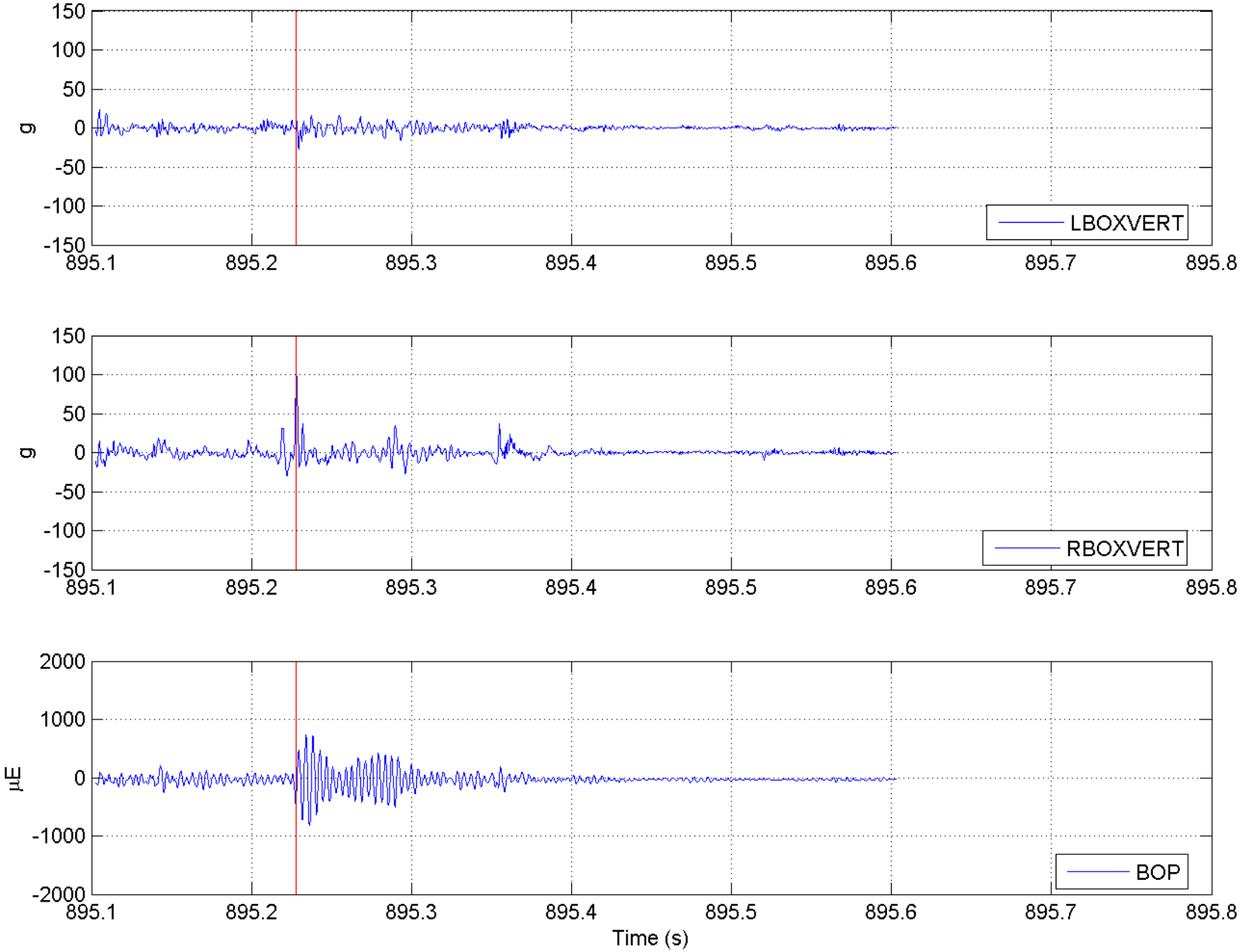
ile 061705_13.AB3, Location 892.407 s, LBOXVERT = 136.45 g, RBOXVERT = 87.78 g, BOP = 1229.5 uE, Speed = 109.1726 mph, Brake Pressure = 0.465



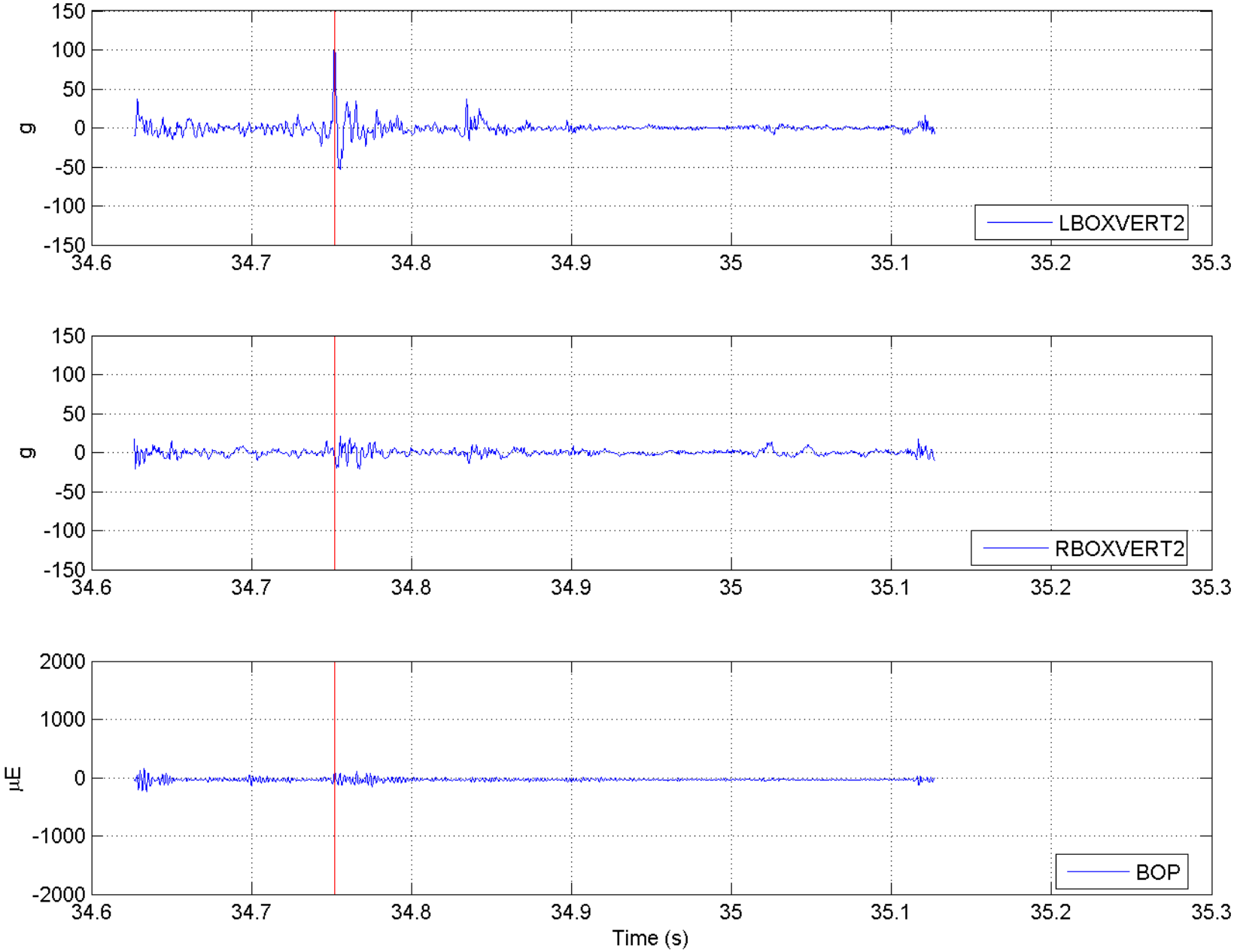
le 061705_13.AB3, Location 674.1803 s, LBOXVERT2 = 41.24 g, RBOXVERT2 = 110.76 g, BOP = 313 uE, Speed = 119.1551 mph, Brake Pressure = 28.3

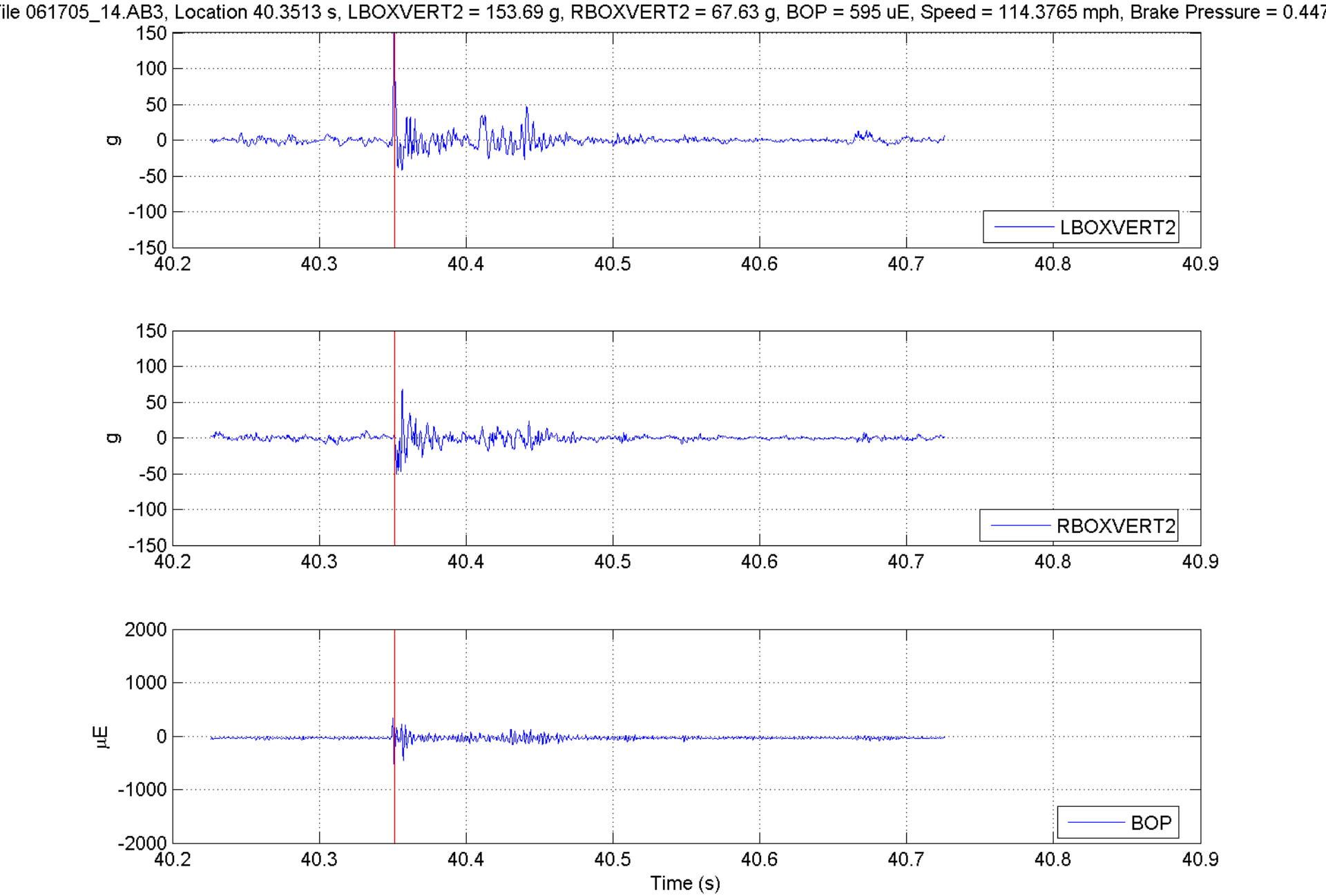


File 061705_13.AB3, Location 895.228 s, LBOXVERT = 26.56 g, RBOXVERT = 103.15 g, BOP = 812 uE, Speed = 108.8588 mph, Brake Pressure = 0.4518

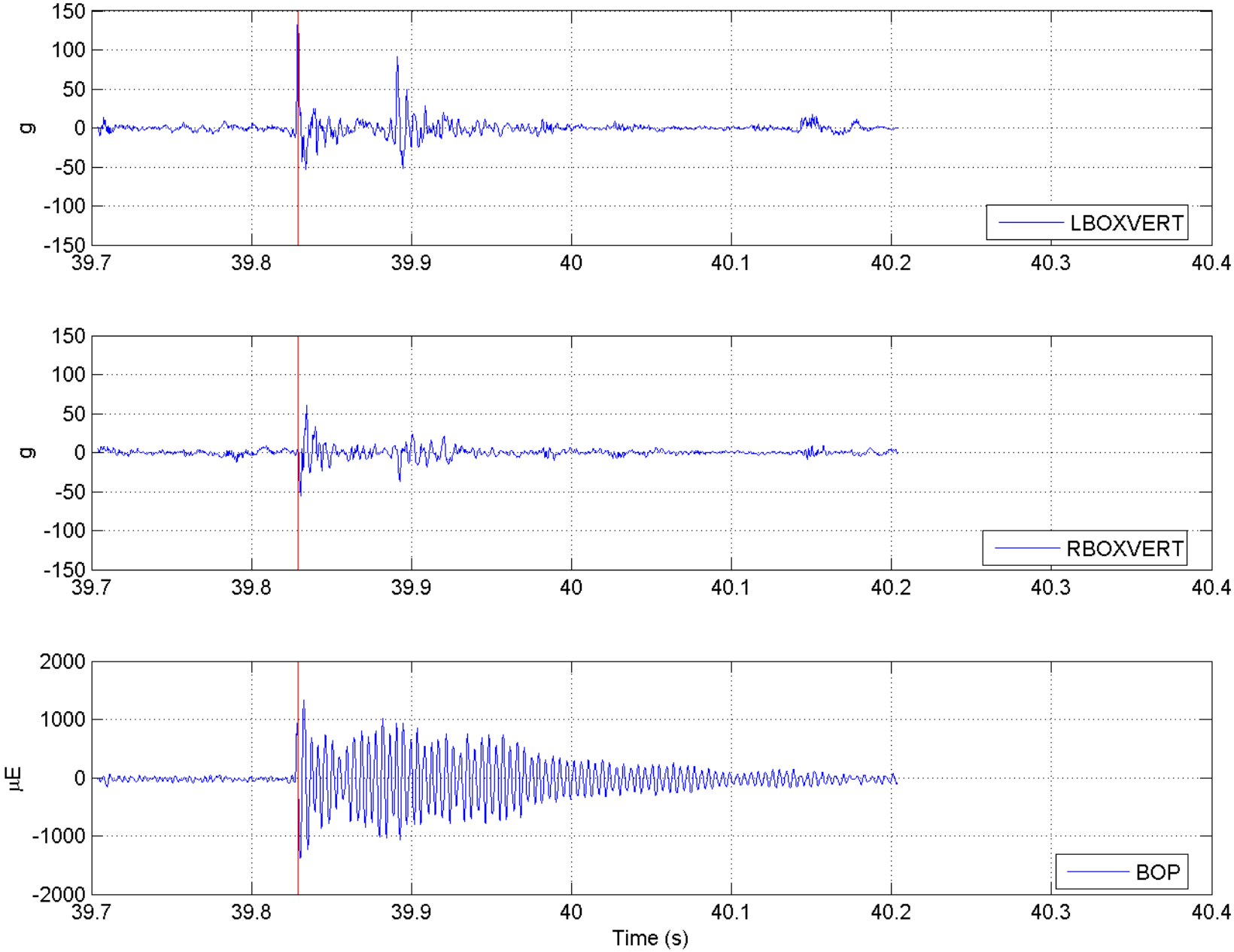


File 061705_14.AB3, Location 34.752 s, LBOXVERT2 = 104.75 g, RBOXVERT2 = 21.56 g, BOP = 244 uE, Speed = 110.9577 mph, Brake Pressure = 0.466

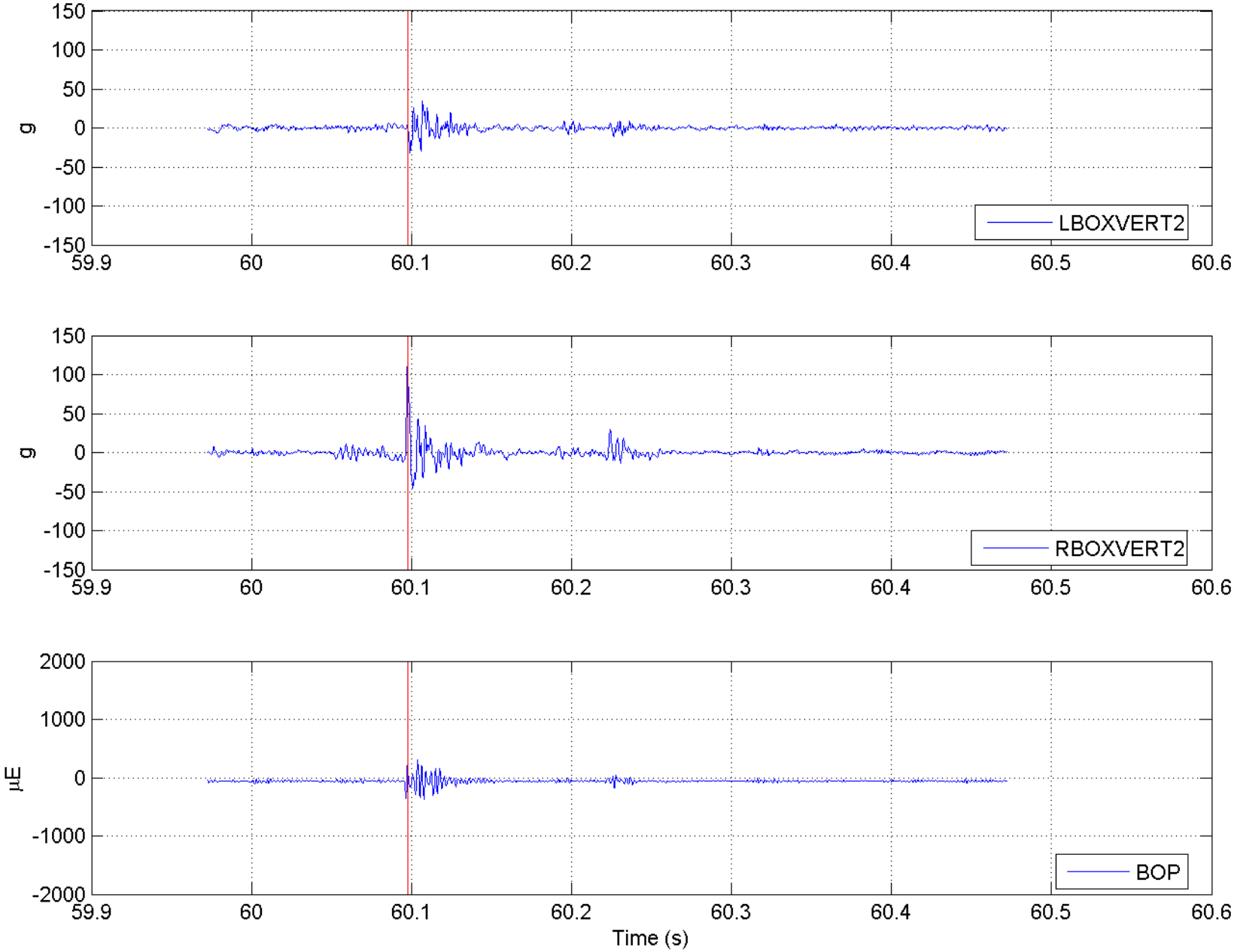



File 061705_14.AB3, Location 40.3513 s, LBOXVERT2 = 153.69 g, RBOXVERT2 = 67.63 g, BOP = 595 uE, Speed = 114.3765 mph, Brake Pressure = 0.447
g
LBOXVERT2
RBOXVERT2
µE
BOP
Time (s)
150
100
50
0
-50
-100
-150
2000
1000
-1000
-2000
40.2
40.3
40.4
40.5
40.6
40.7
40.8
40.9

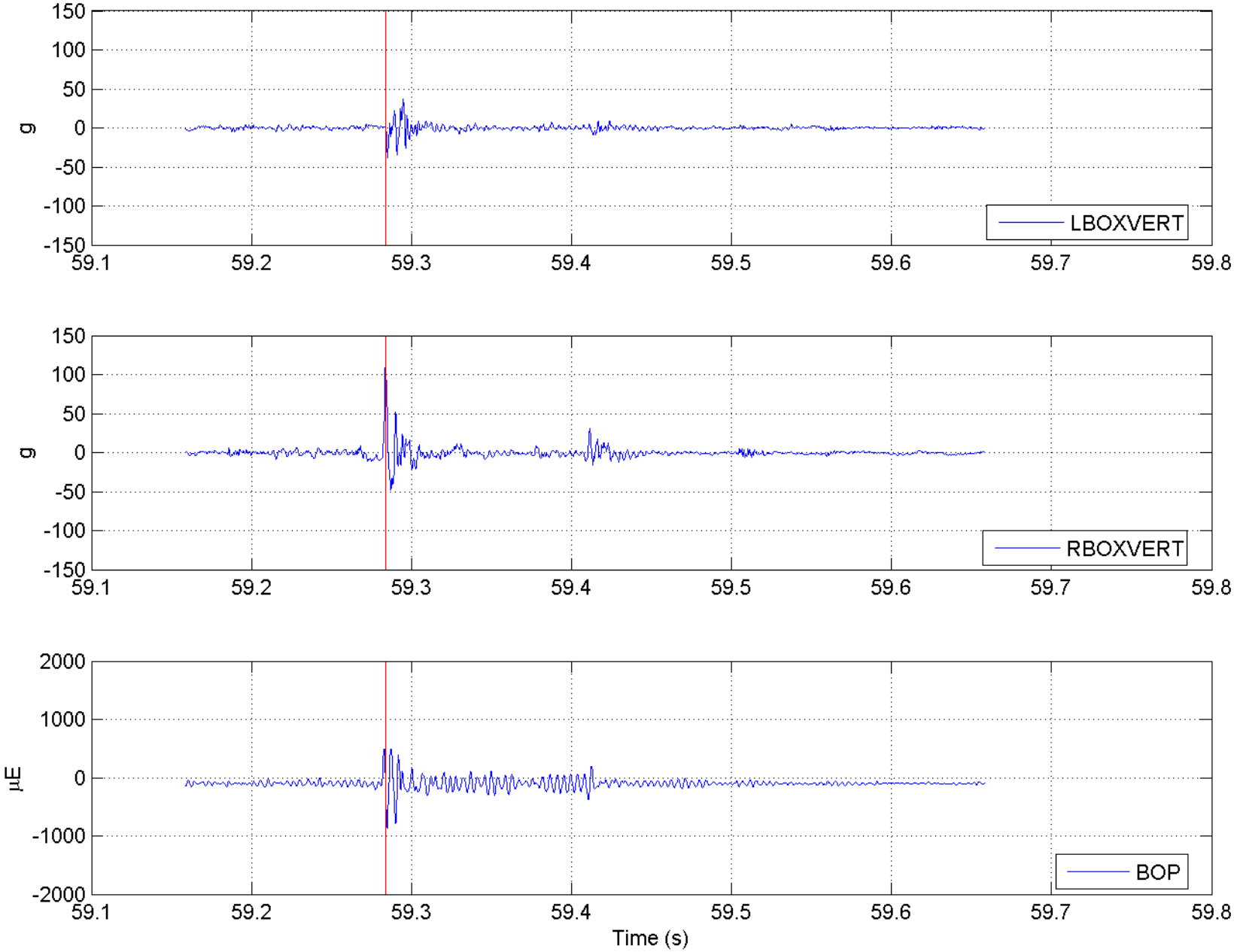
File 061705_14.AB3, Location 39.829 s, LBOXVERT = 161.93 g, RBOXVERT = 60.5 g, BOP = 1378.5 uE, Speed = 114.1452 mph, Brake Pressure = 0.4737



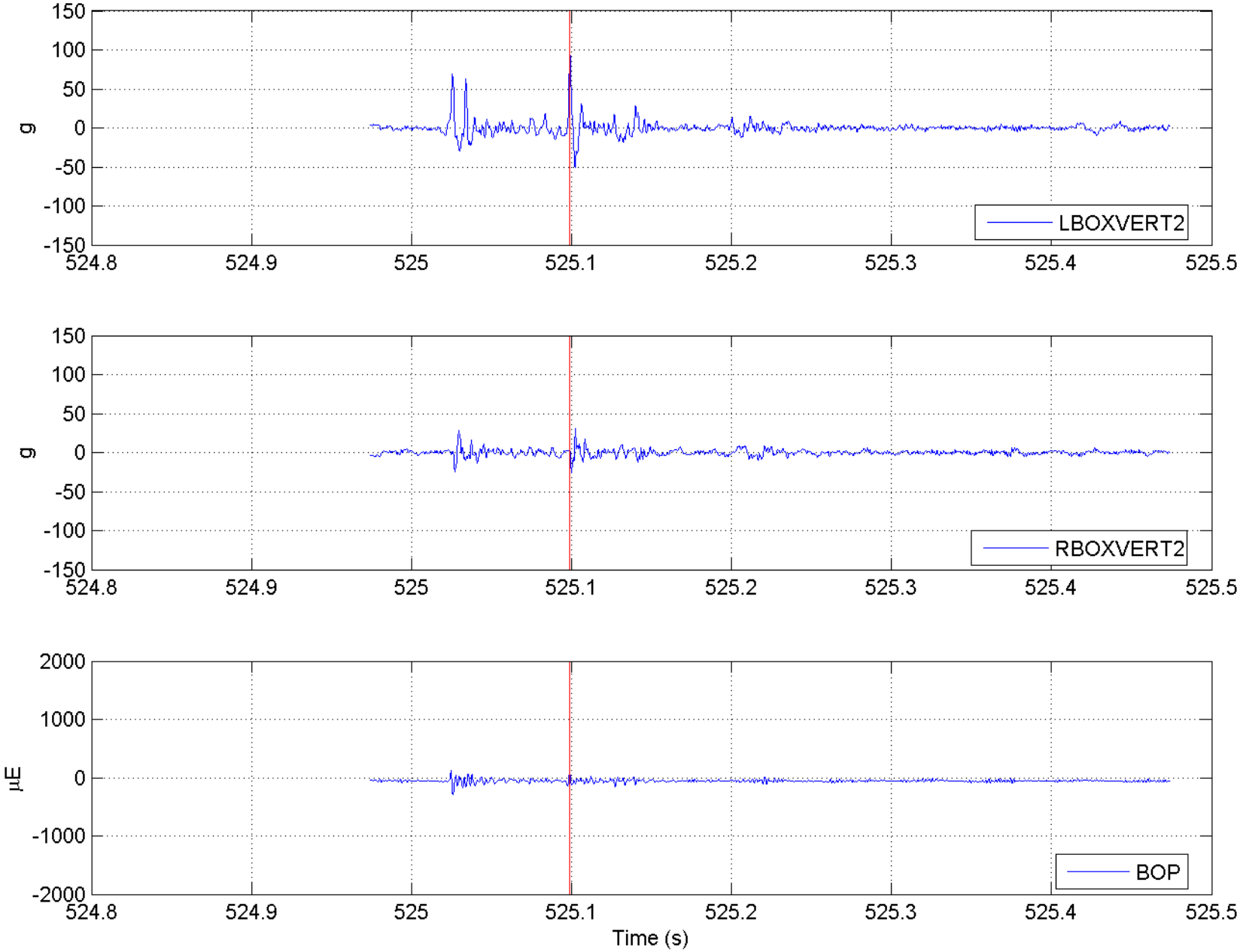
ile 061705_15.AB3, Location 60.0977 s, LBOXVERT2 = 34.09 g, RBOXVERT2 = 117.02 g, BOP = 377.5 uE, Speed = 73.5116 mph, Brake Pressure = 0.45



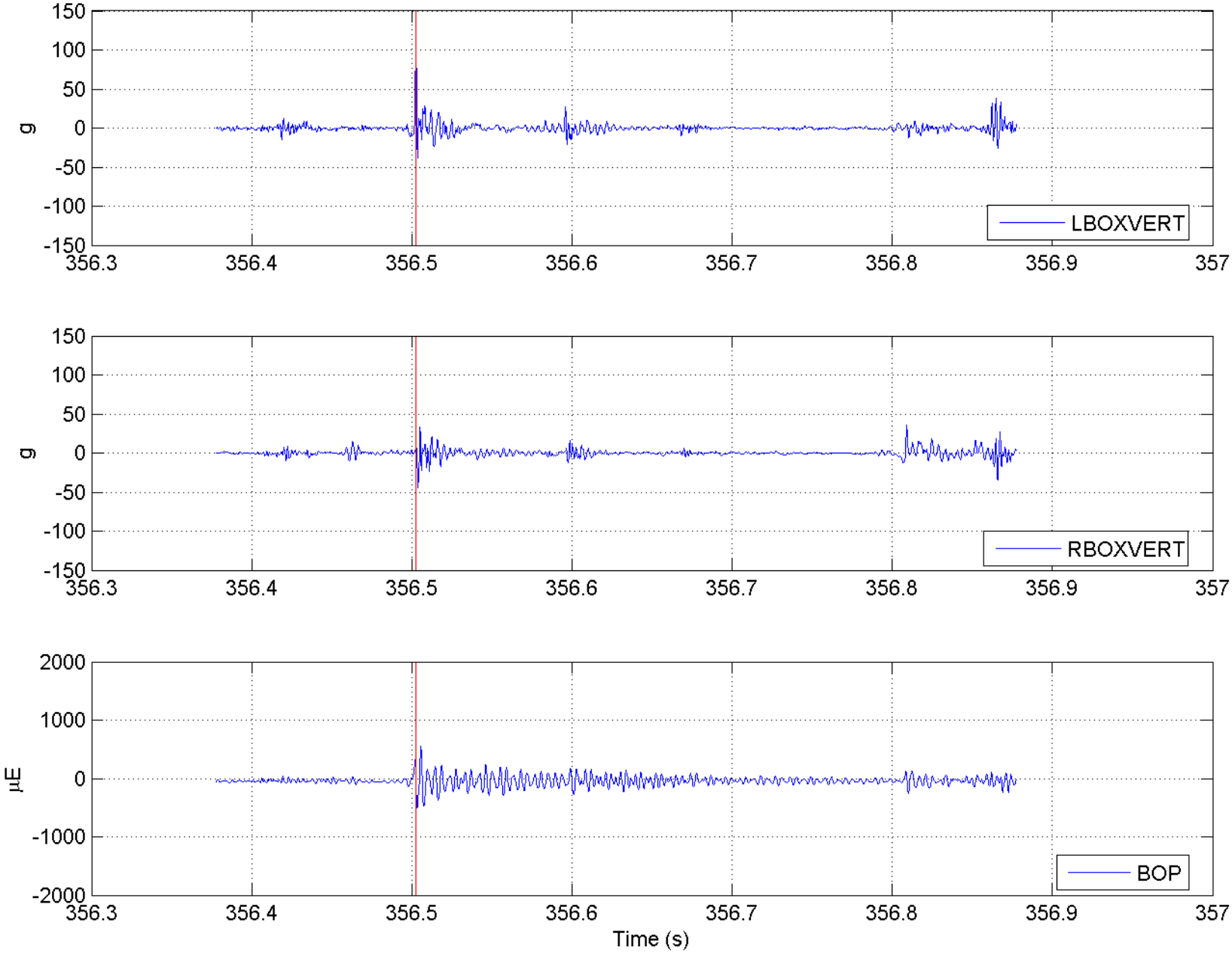
File 061705_15.AB3, Location 59.2837 s, LBOXVERT = 38.1 g, RBOXVERT = 118.21 g, BOP = 866 uE, Speed = 72.9994 mph, Brake Pressure = 0.45977



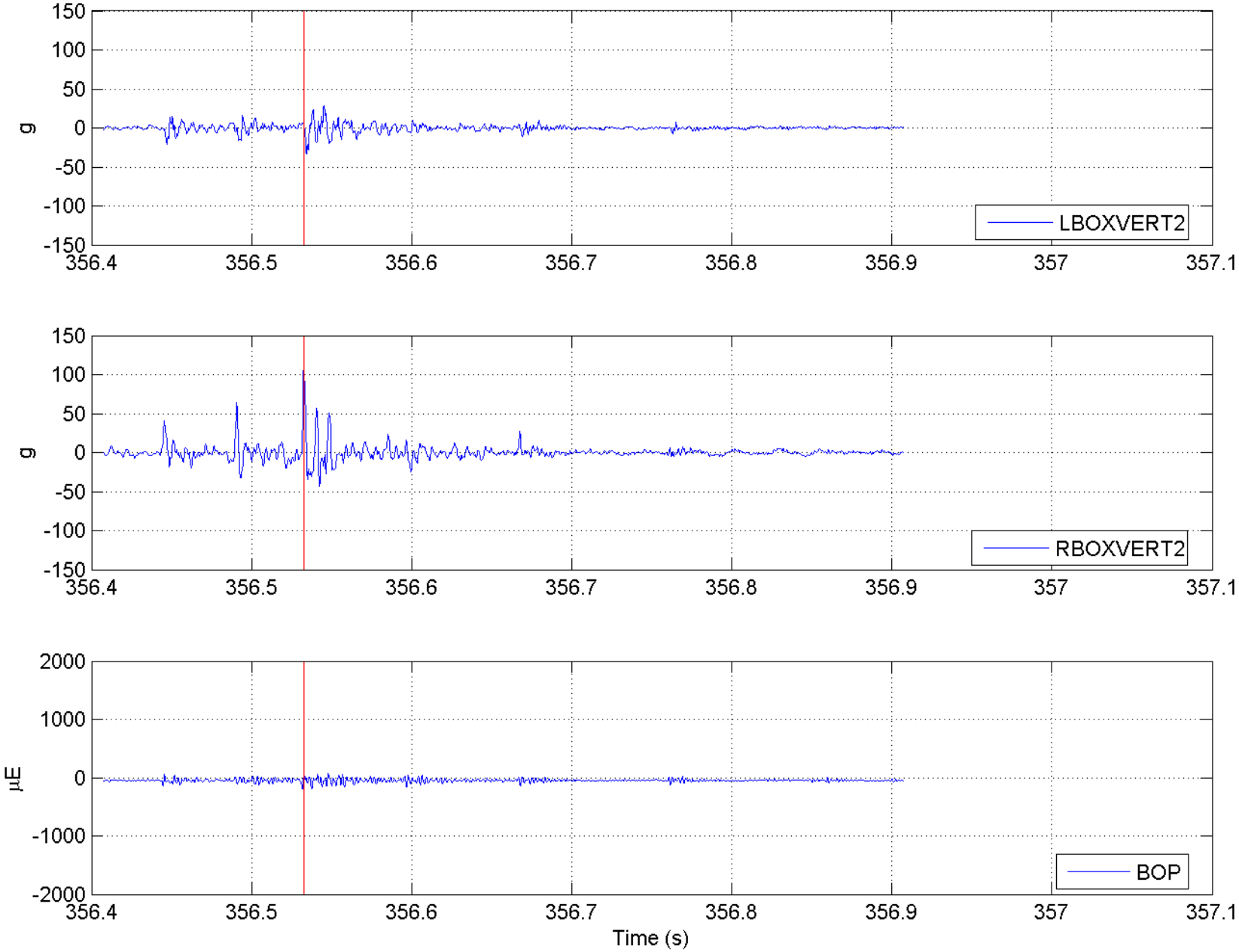
File 061705_21.AB3, Location 525.099 s, LBOXVERT2 = 100.02 g, RBOXVERT2 = 30.38 g, BOP = 284 uE, Speed = 68.0643 mph, Brake Pressure = 14.69



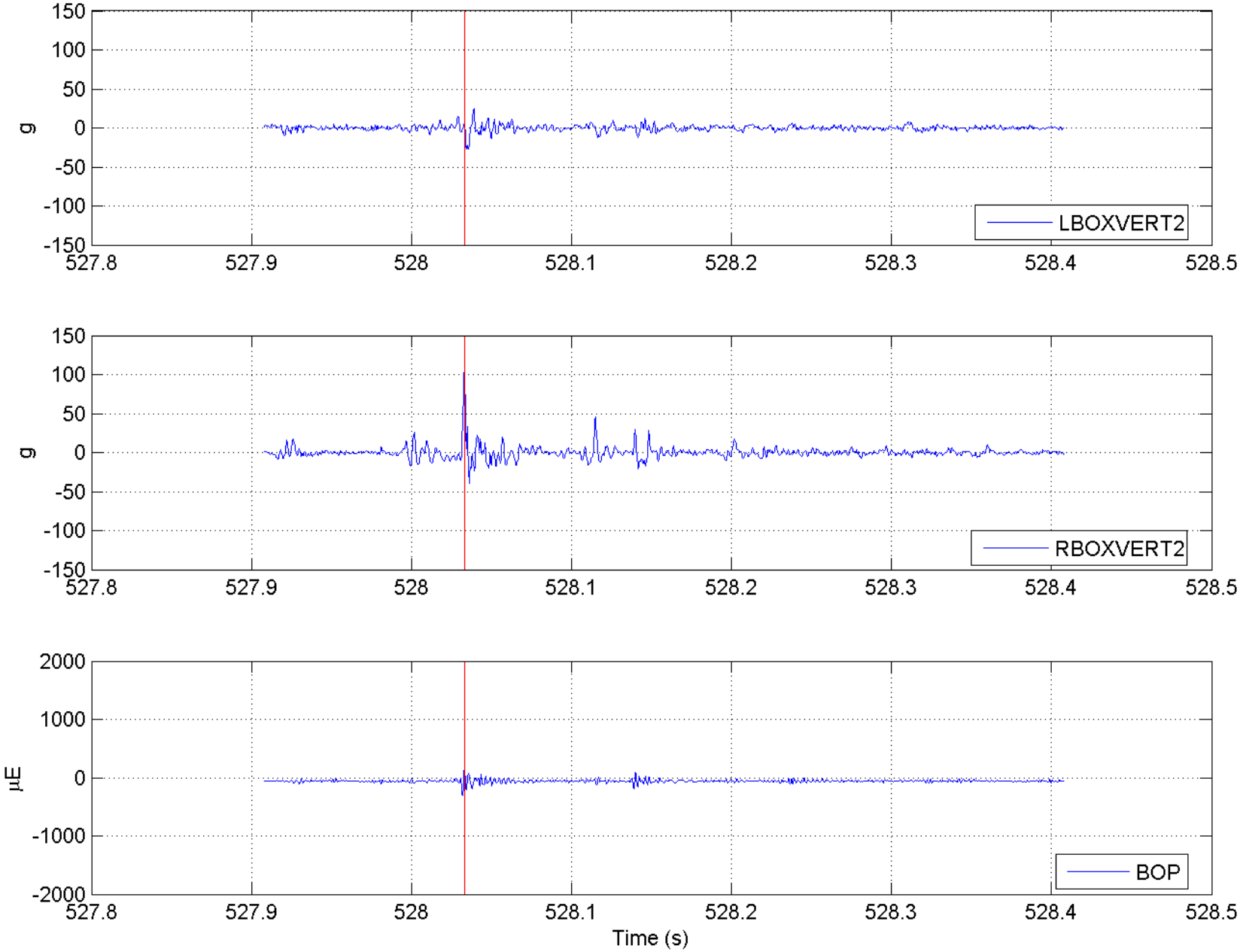
File 061705_21.AB3, Location 356.5027 s, LBOXVERT = 101.83 g, RBOXVERT = 44.06 g, BOP = 553.5 uE, Speed = 73.2233 mph, Brake Pressure = 0.464



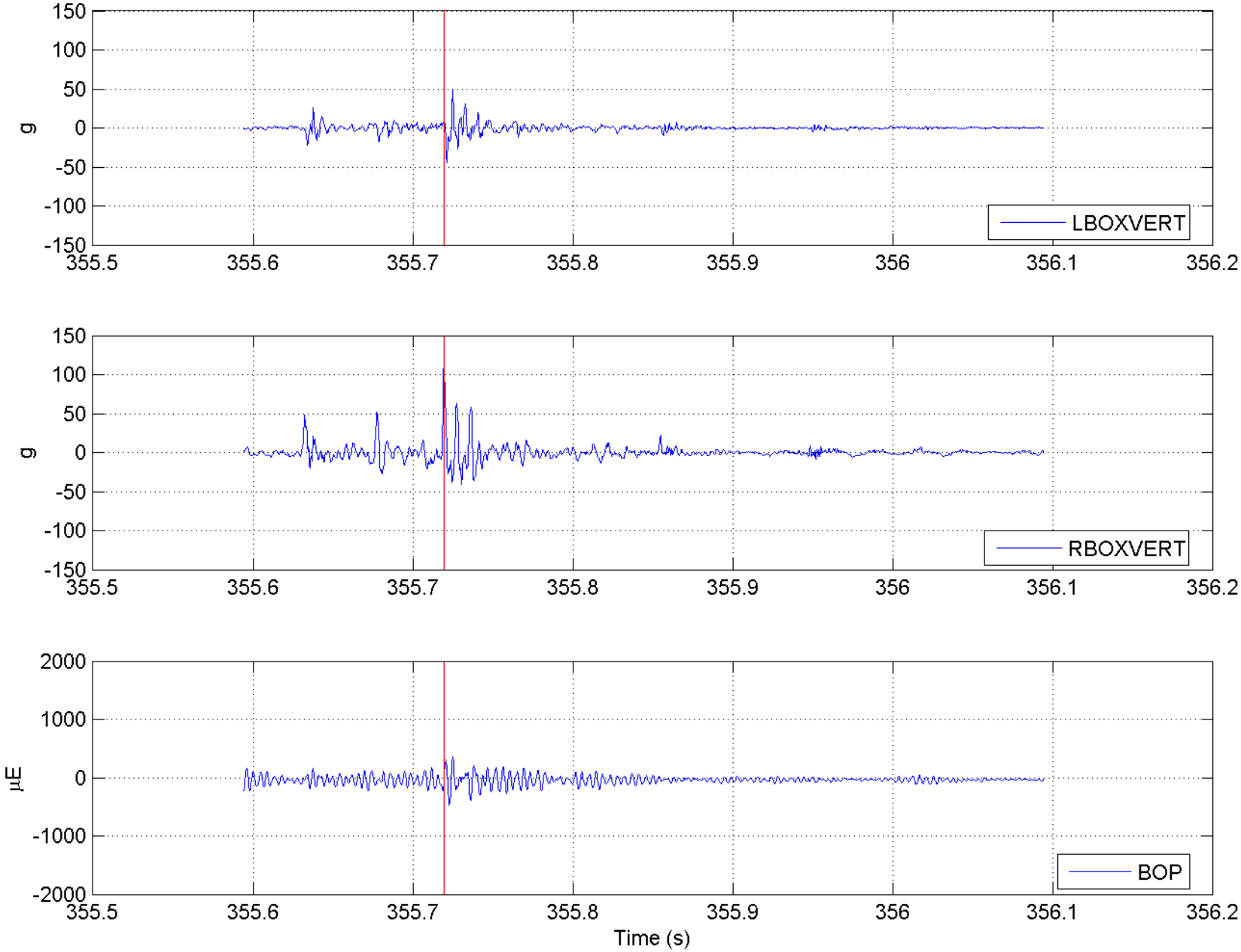
le 061705_21.AB3, Location 356.5327 s, LBOXVERT2 = 33.29 g, RBOXVERT2 = 119.15 g, BOP = 195.5 uE, Speed = 73.1958 mph, Brake Pressure = 0.46



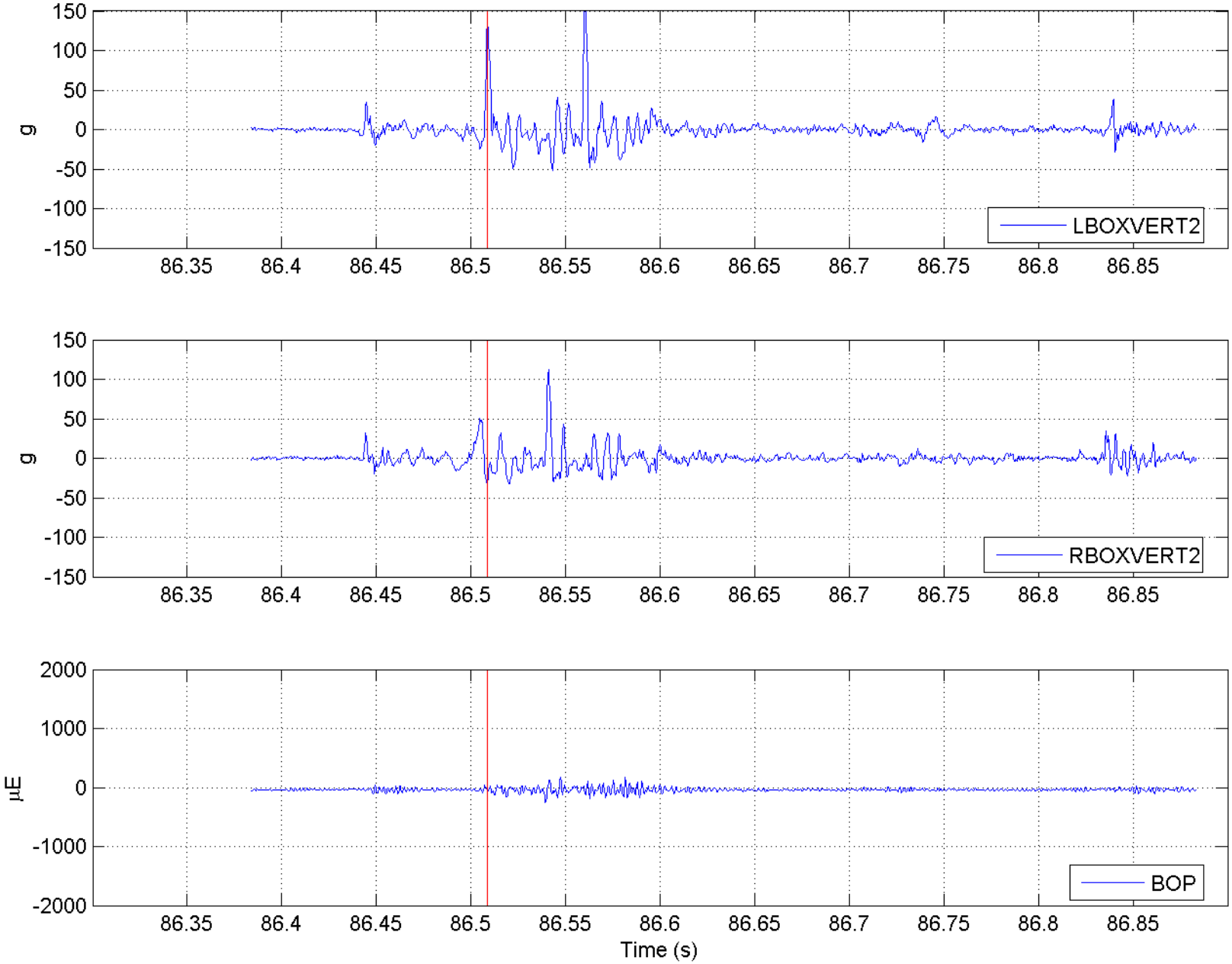
File 061705_21.AB3, Location 528.033 s, LBOXVERT2 = 26.99 g, RBOXVERT2 = 106.19 g, BOP = 313 uE, Speed = 64.6524 mph, Brake Pressure = 15.13

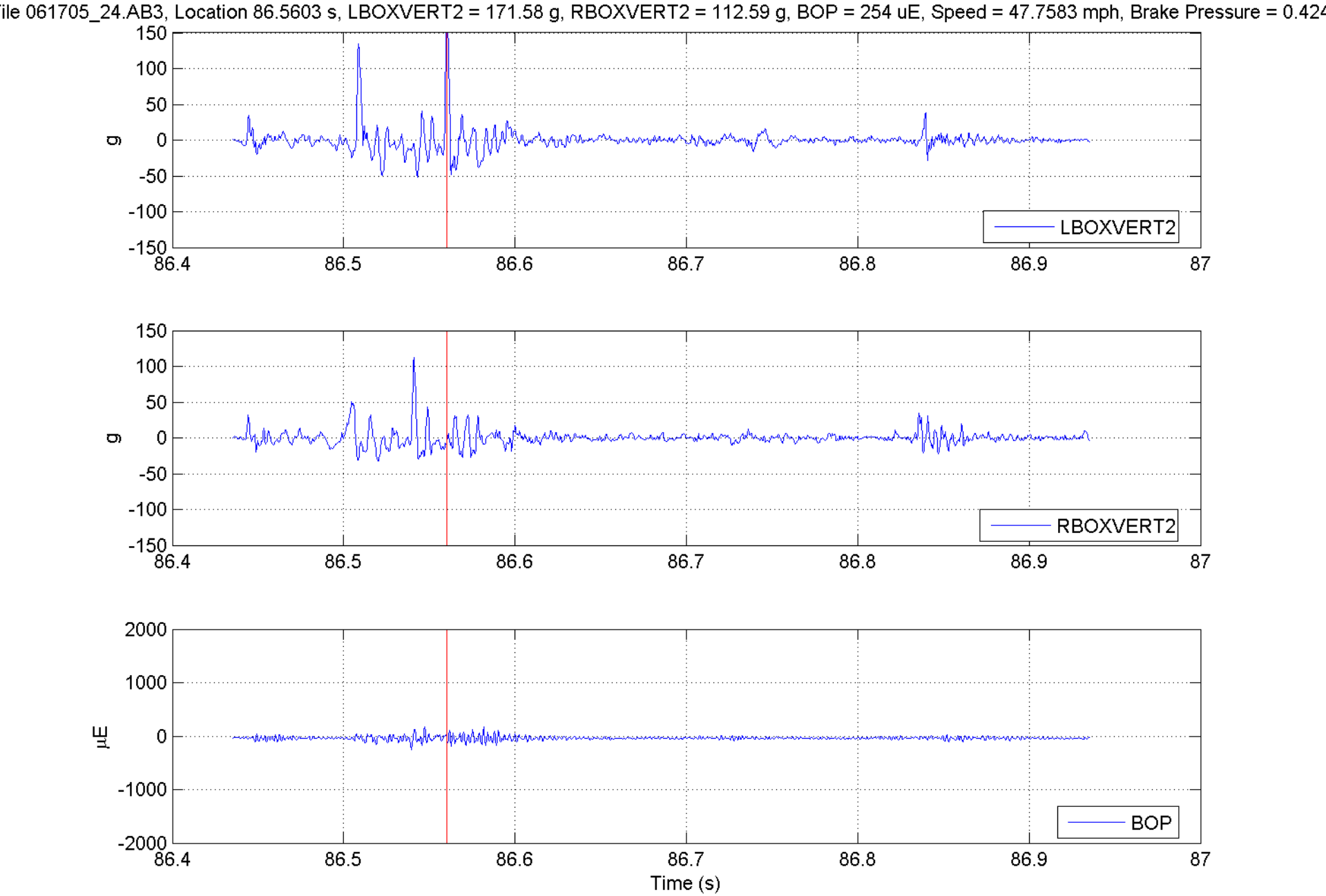


File 061705_21.AB3, Location 355.7193 s, LBOXVERT = 48.54 g, RBOXVERT = 120.7 g, BOP = 463 uE, Speed = 73.3213 mph, Brake Pressure = 0.4599

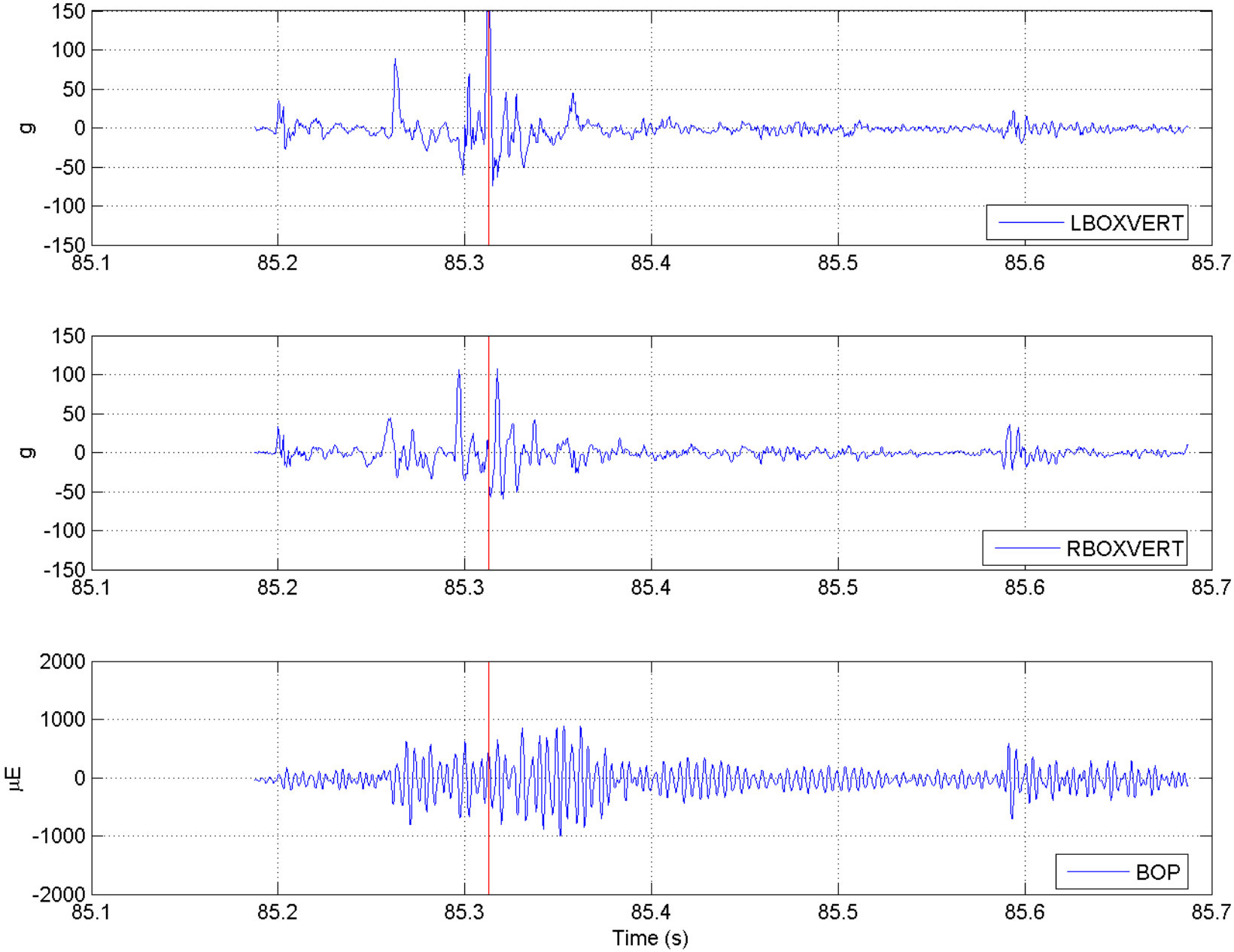


File 061705_24.AB3, Location 86.5087 s, LBOXVERT2 = 171.58 g, RBOXVERT2 = 112.59 g, BOP = 254 uE, Speed = 47.7727 mph, Brake Pressure = 0.42

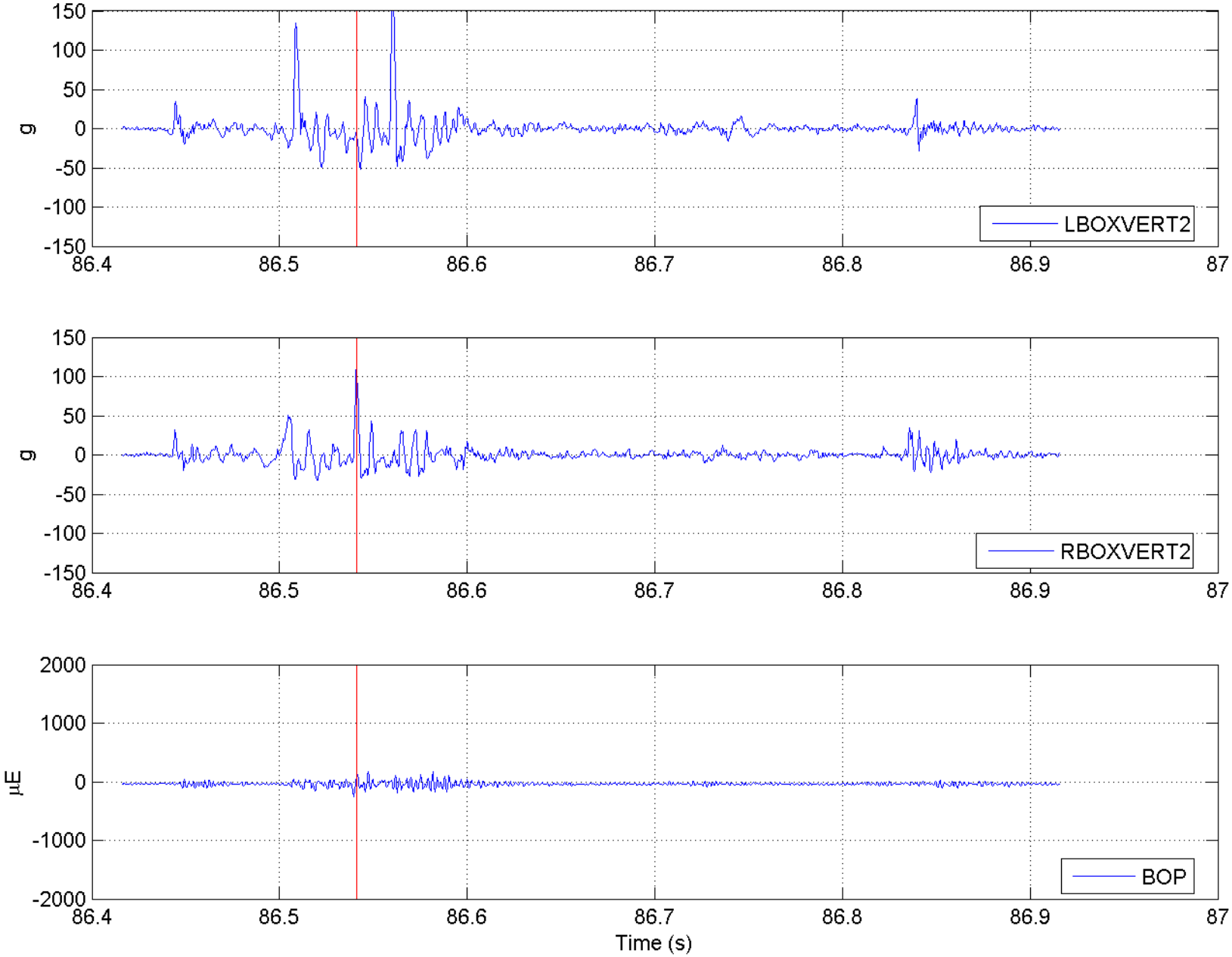



File 061705_24.AB3, Location 86.5603 s, LBOXVERT2 = 171.58 g, RBOXVERT2 = 112.59 g, BOP = 254 uE, Speed = 47.7583 mph, Brake Pressure = 0.424
g
LBOXVERT2
RBOXVERT2
µE
BOP
Time (s)
150
100
50
0
-50
-100
-150
2000
1000
-1000
-2000
86.4
86.5
86.6
86.7
86.8
86.9
87

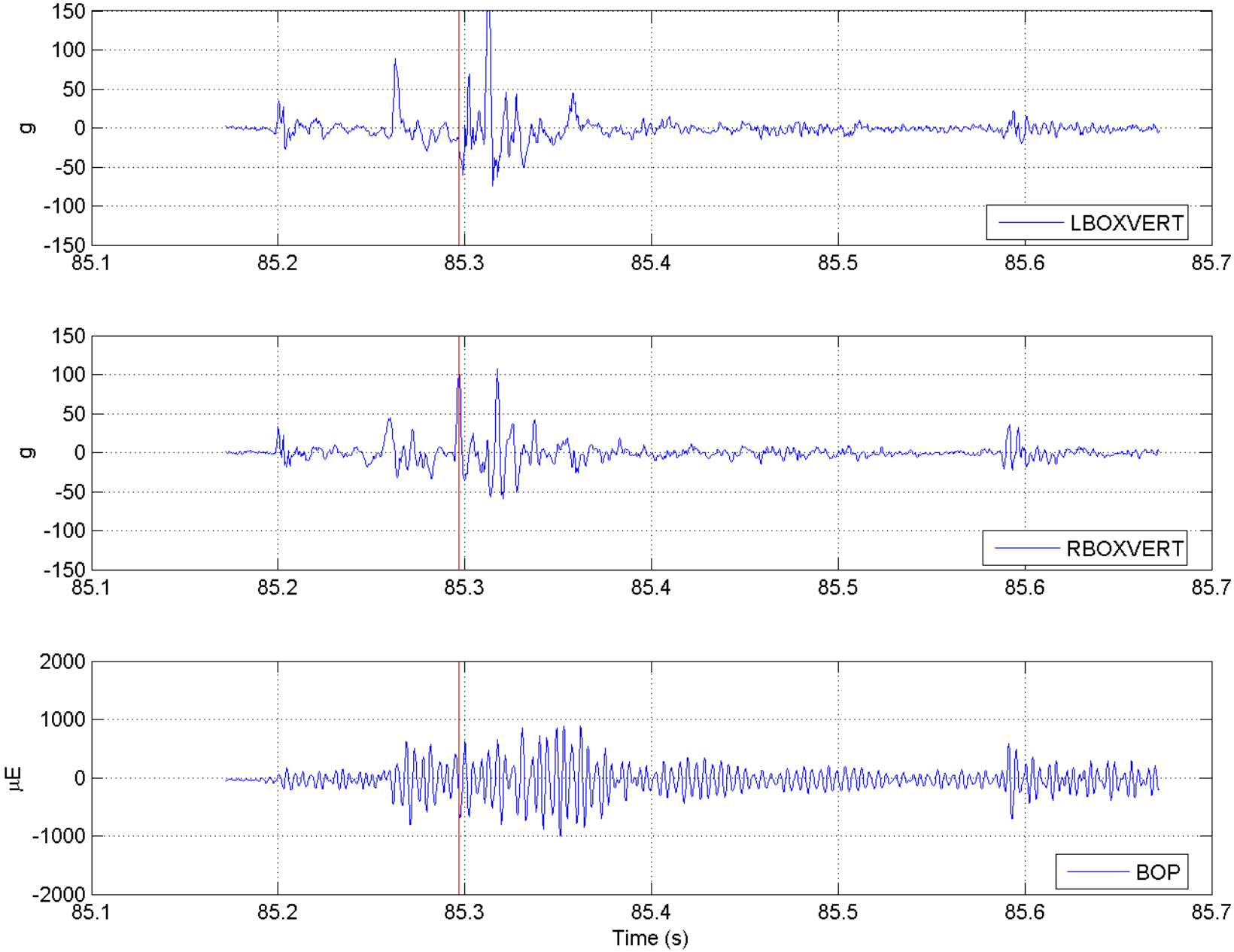
File 061705_24.AB3, Location 85.3127 s, LBOXVERT = 188.85 g, RBOXVERT = 107.25 g, BOP = 1003 uE, Speed = 47.8865 mph, Brake Pressure = 0.350



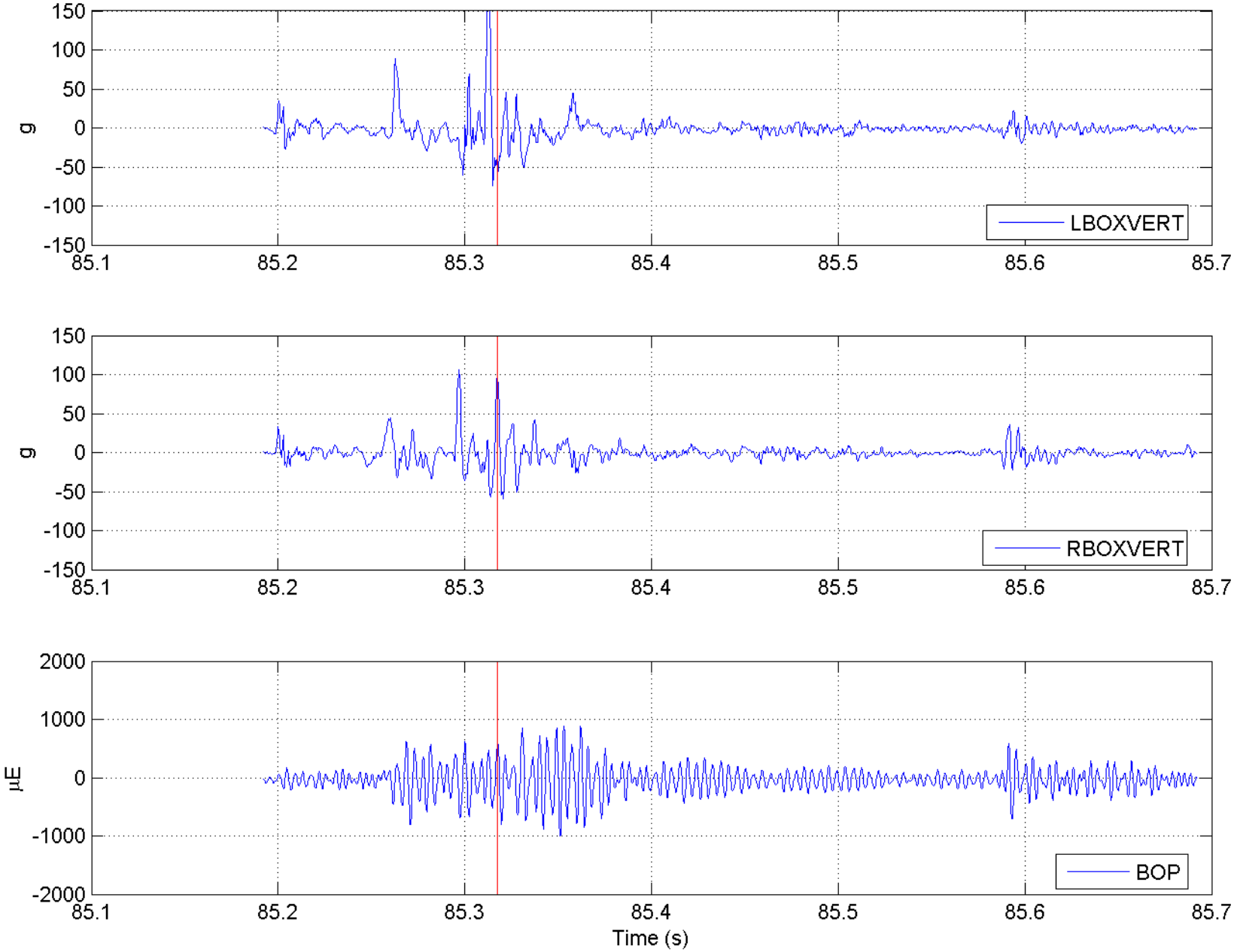
File 061705_24.AB3, Location 86.541 s, LBOXVERT2 = 171.58 g, RBOXVERT2 = 112.59 g, BOP = 254 uE, Speed = 47.7535 mph, Brake Pressure = 0.424



File 061705_24.AB3, Location 85.297 s, LBOXVERT = 188.85 g, RBOXVERT = 107.25 g, BOP = 1003 uE, Speed = 47.8994 mph, Brake Pressure = 0.3528



File 061705_24.AB3, Location 85.3173 s, LBOXVERT = 188.85 g, RBOXVERT = 107.25 g, BOP = 1003 uE, Speed = 47.8798 mph, Brake Pressure = 0.350



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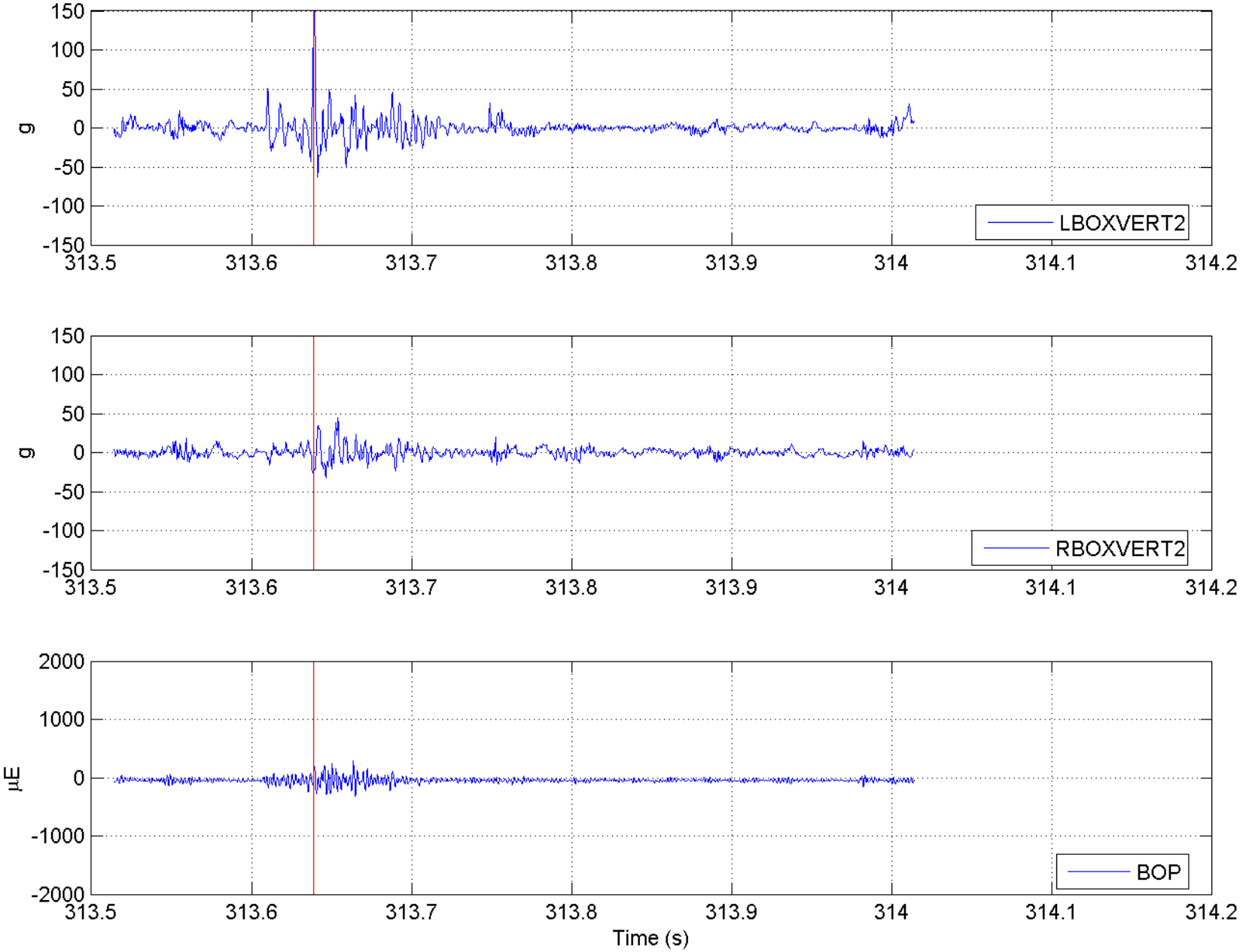
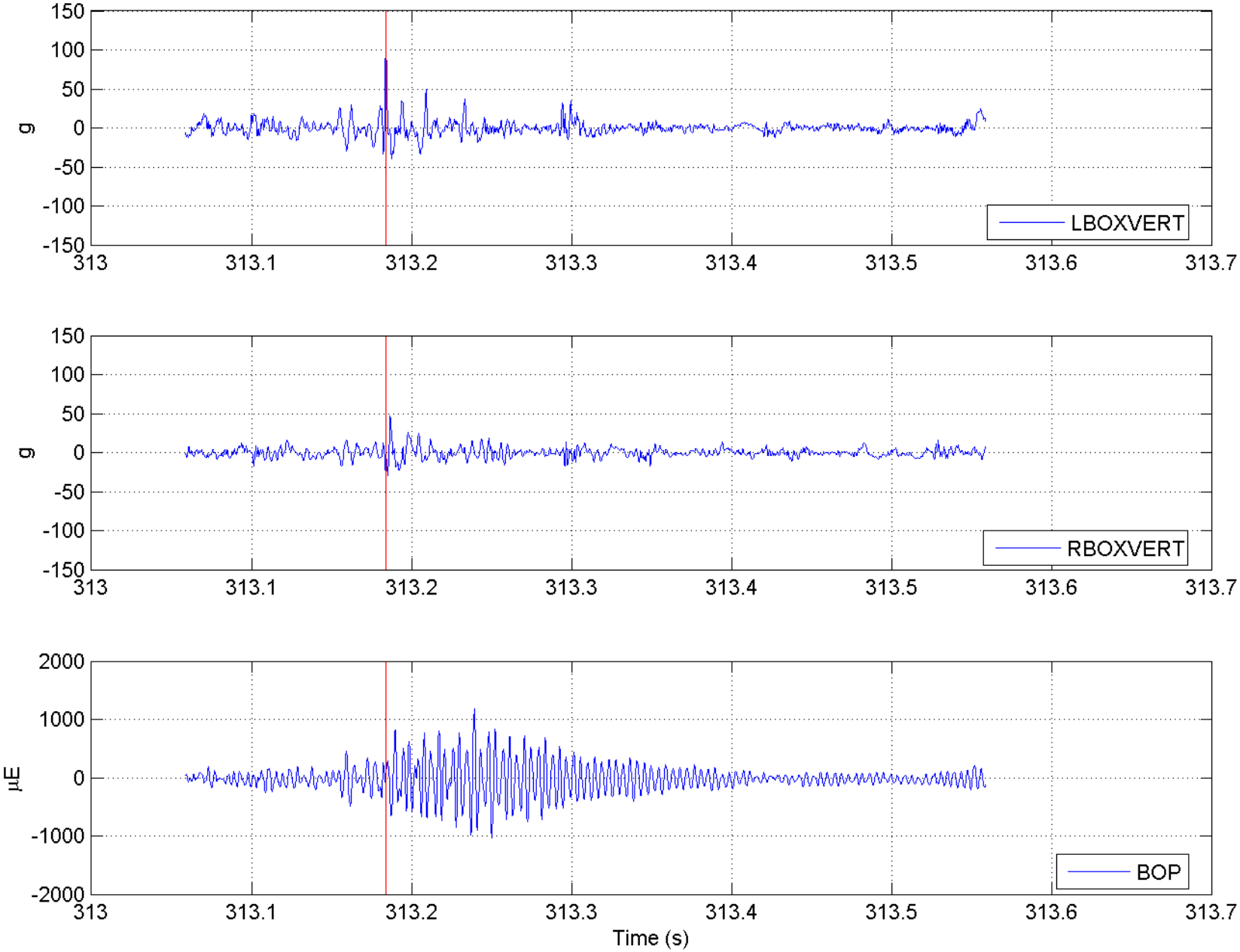
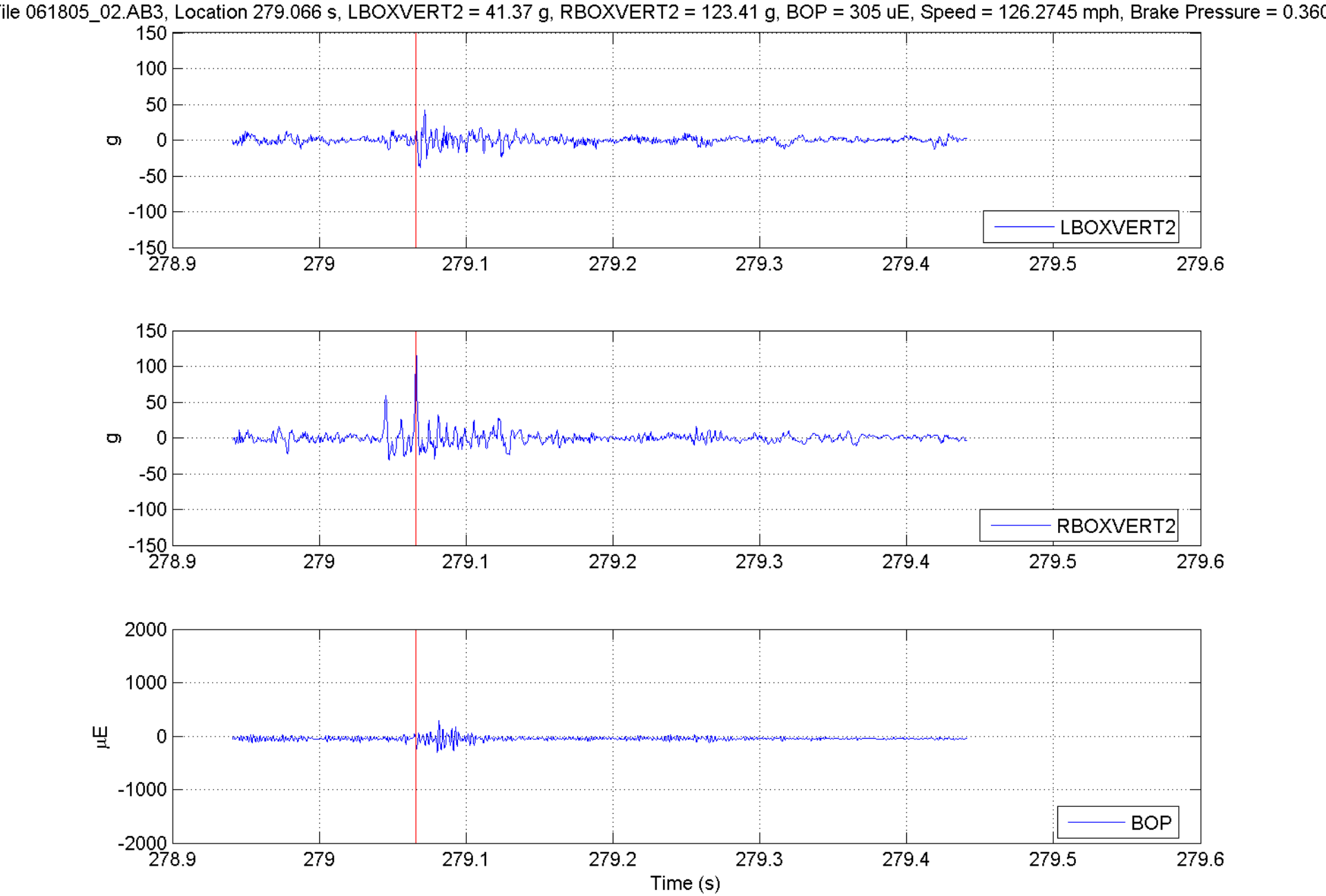
ile 061805_02.AB3, Location 313.639 s, LBOXVERT2 = 178.27 g, RBOXVERT2 = 44.44 g, BOP = 326 uE, Speed = 131.2046 mph, Brake Pressure = 0.349

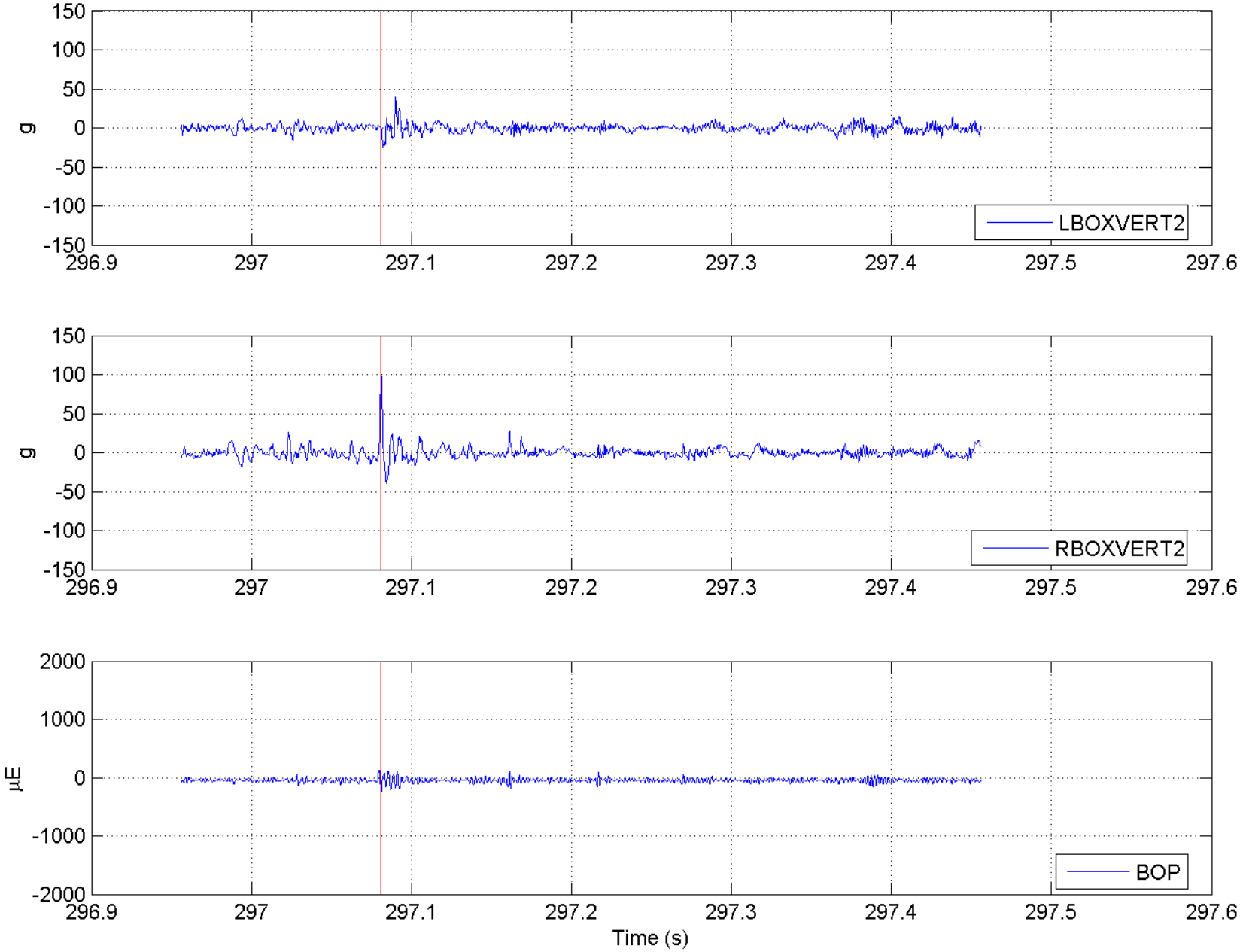


e 061805_02.AB3, Location 313.1837 s, LBOXVERT = 106.17 g, RBOXVERT = 47.27 g, BOP = 1174.5 uE, Speed = 131.0879 mph, Brake Pressure = 0.36

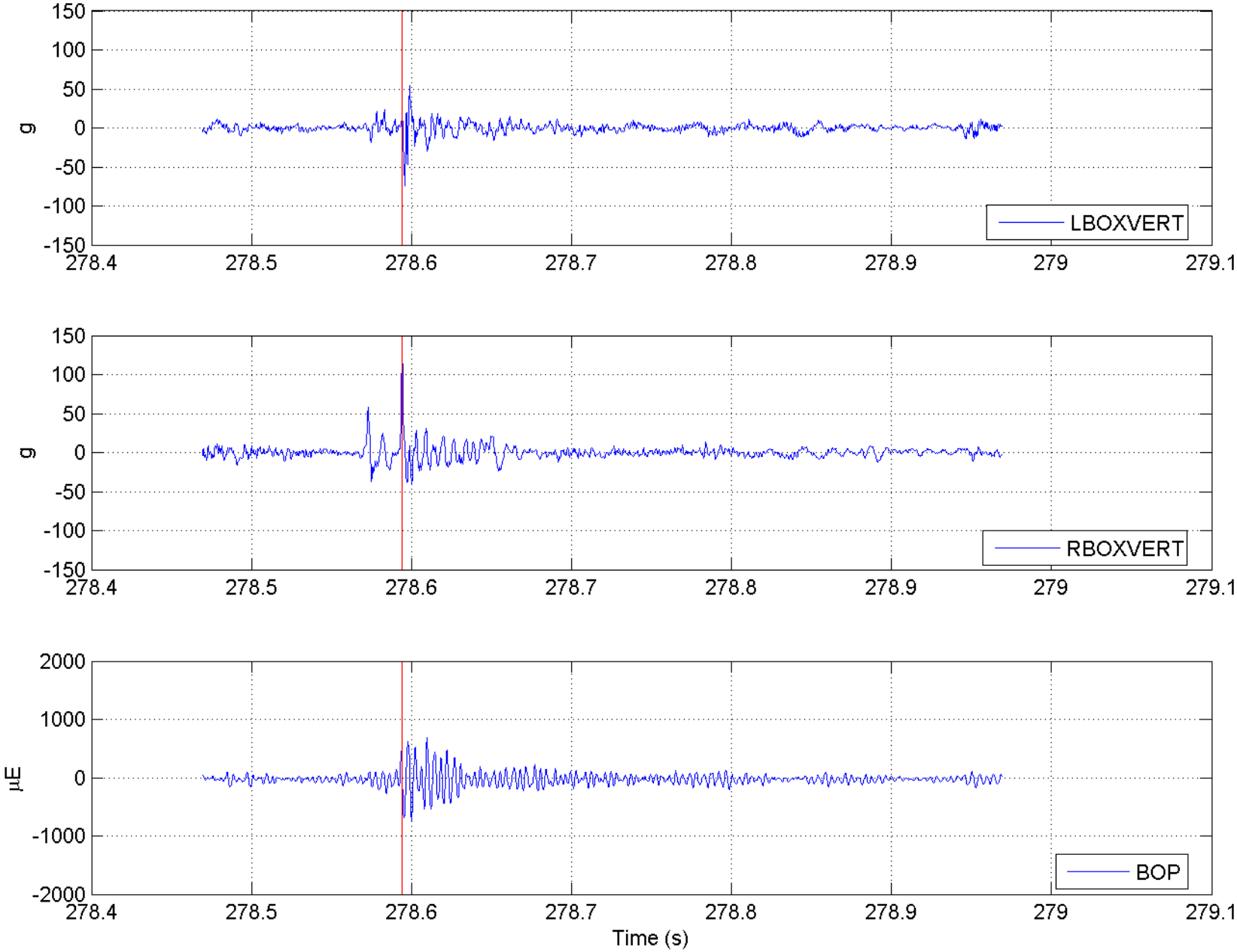



File 061805_02.AB3, Location 279.066 s, LBOXVERT2 = 41.37 g, RBOXVERT2 = 123.41 g, BOP = 305 uE, Speed = 126.2745 mph, Brake Pressure = 0.360
g
LBOXVERT2
RBOXVERT2
µE
BOP
Time (s)
150
100
50
0
-50
-100
-150
2000
1000
-1000
-2000
278.9
279
279.1
279.2
279.3
279.4
279.5
279.6

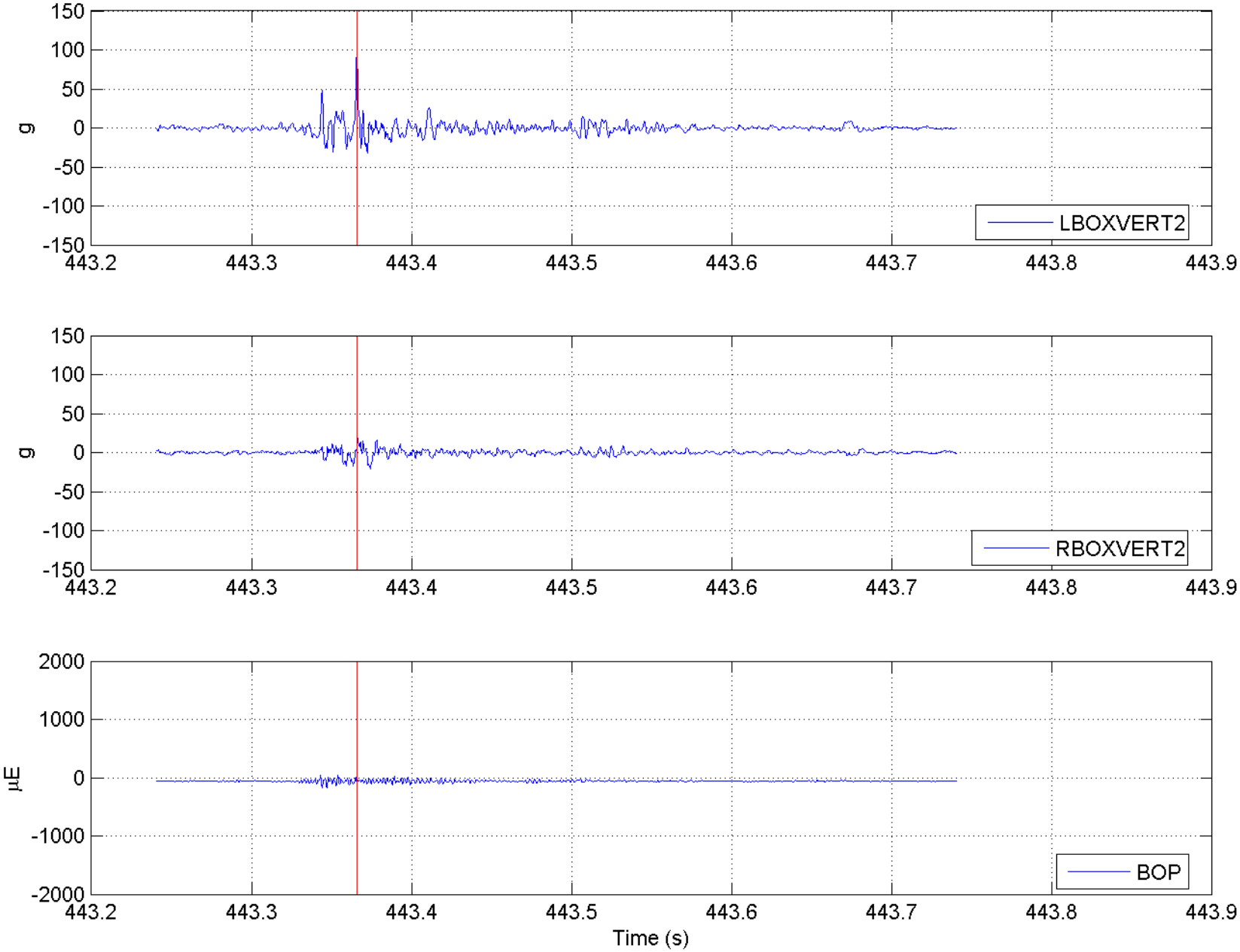
le 061805_02.AB3, Location 297.081 s, LBOXVERT2 = 39.02 g, RBOXVERT2 = 104.19 g, BOP = 285.5 uE, Speed = 125.9096 mph, Brake Pressure = 0.33



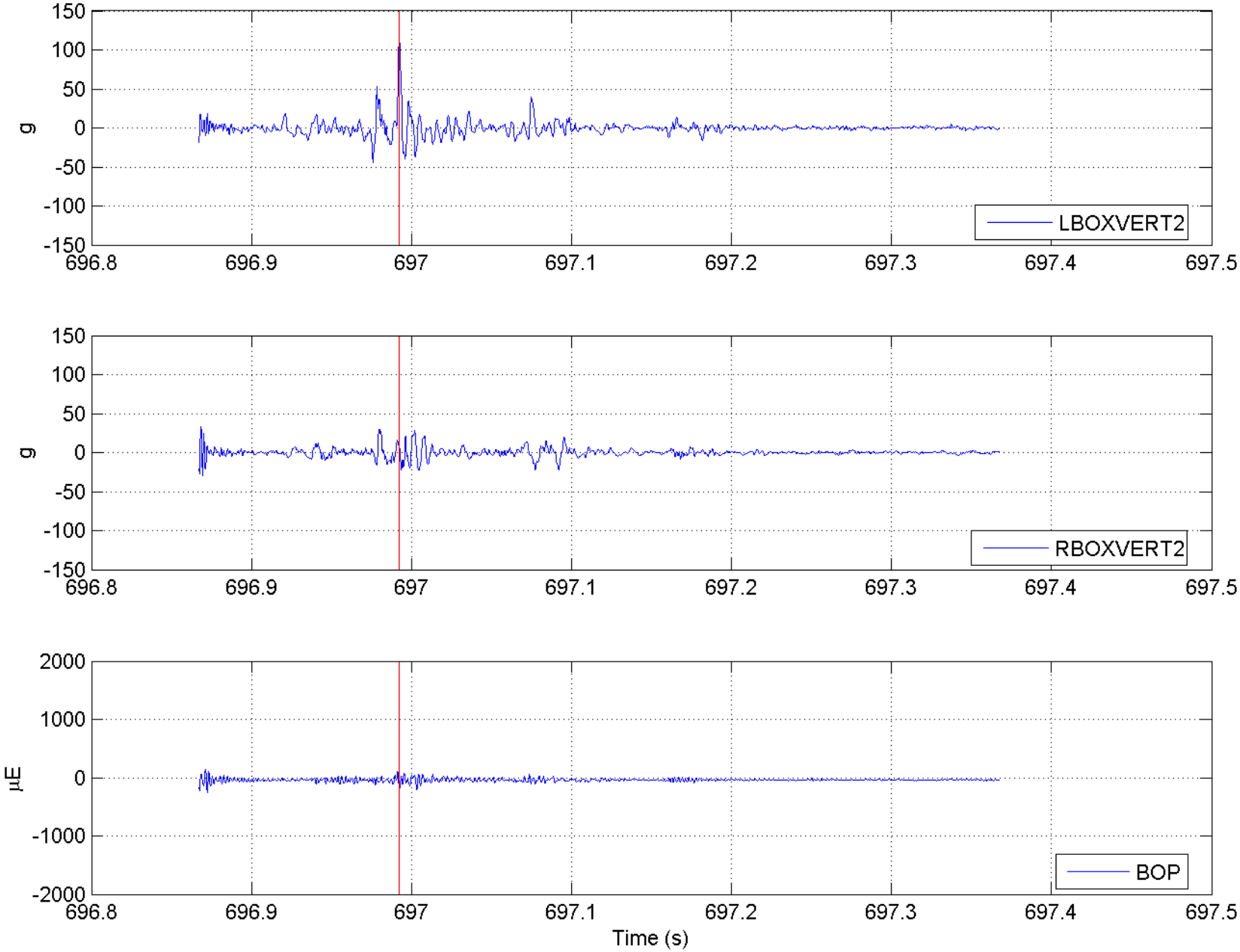
File 061805_02.AB3, Location 278.5943 s, LBOXVERT = 74.21 g, RBOXVERT = 132.34 g, BOP = 737 uE, Speed = 126.1876 mph, Brake Pressure = 0.368



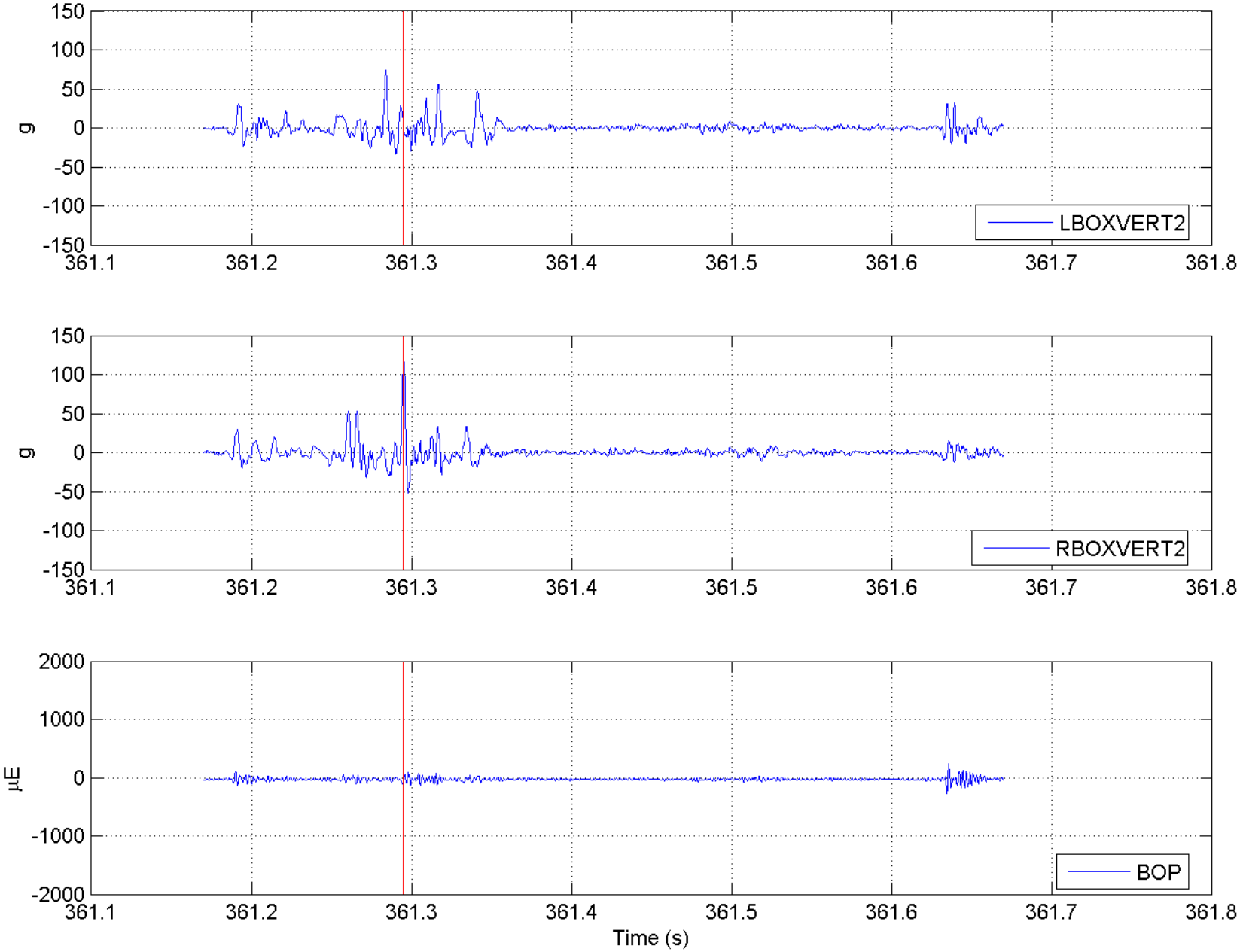
e 061805_12.AB3, Location 443.3657 s, LBOXVERT2 = 101.98 g, RBOXVERT2 = 21.14 g, BOP = 179.5 uE, Speed = 43.9271 mph, Brake Pressure = 0.33



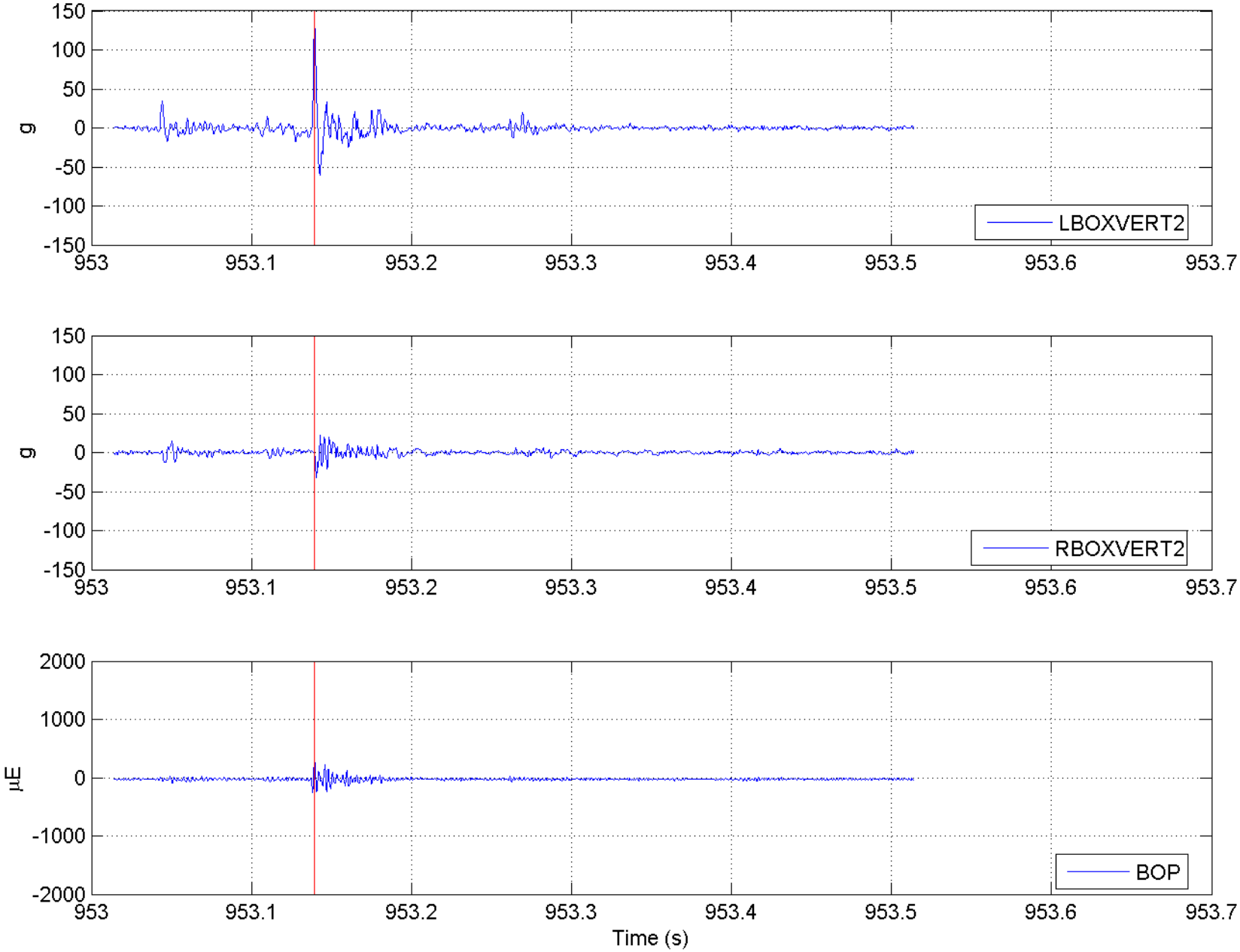
File 061805_12.AB3, Location 696.9923 s, LBOXVERT2 = 113.67 g, RBOXVERT2 = 33.17 g, BOP = 248.5 uE, Speed = 77.42 mph, Brake Pressure = 0.347



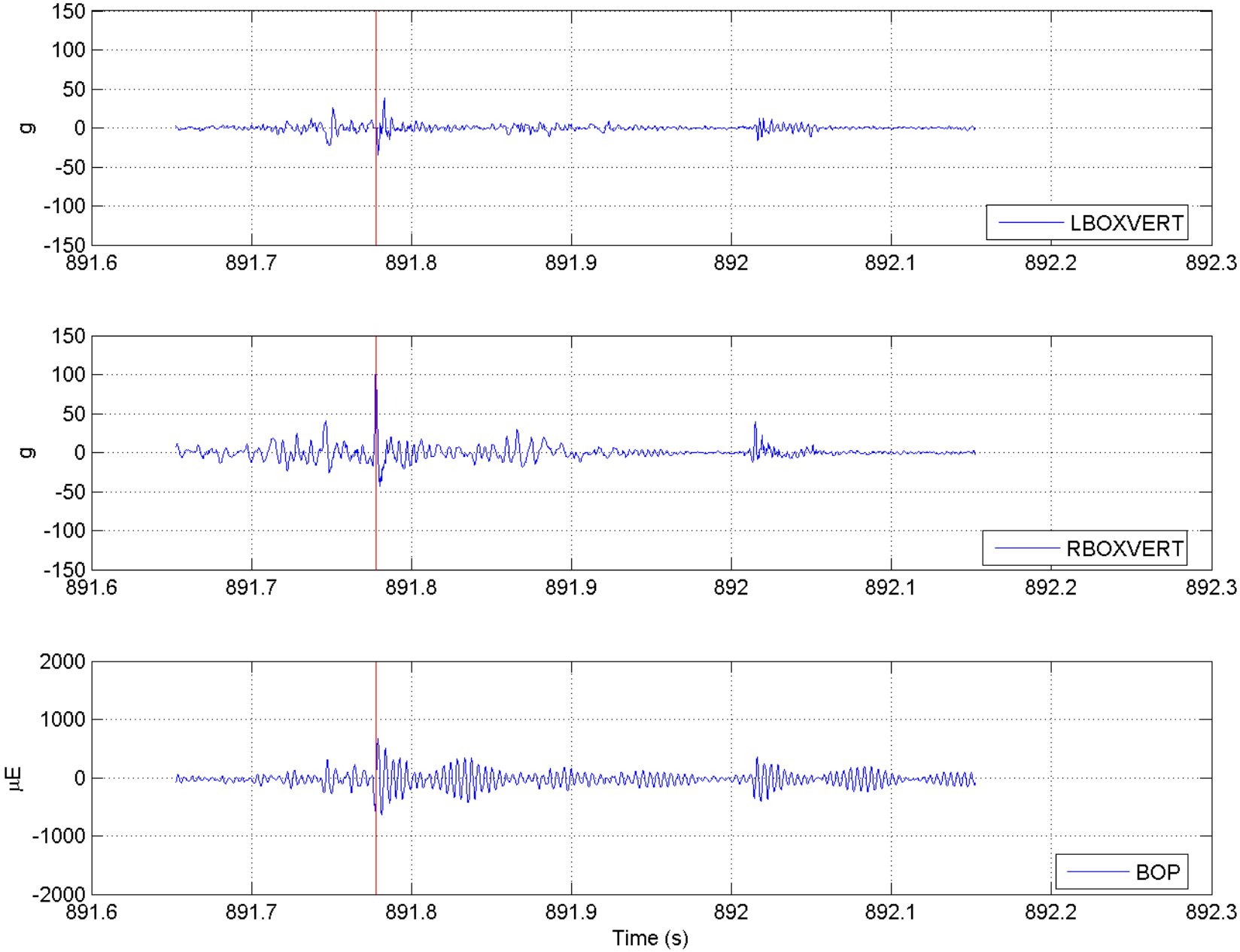
File 061805_13.AB3, Location 361.295 s, LBOXVERT2 = 73.71 g, RBOXVERT2 = 119.2 g, BOP = 268 uE, Speed = 41.9484 mph, Brake Pressure = 0.3507



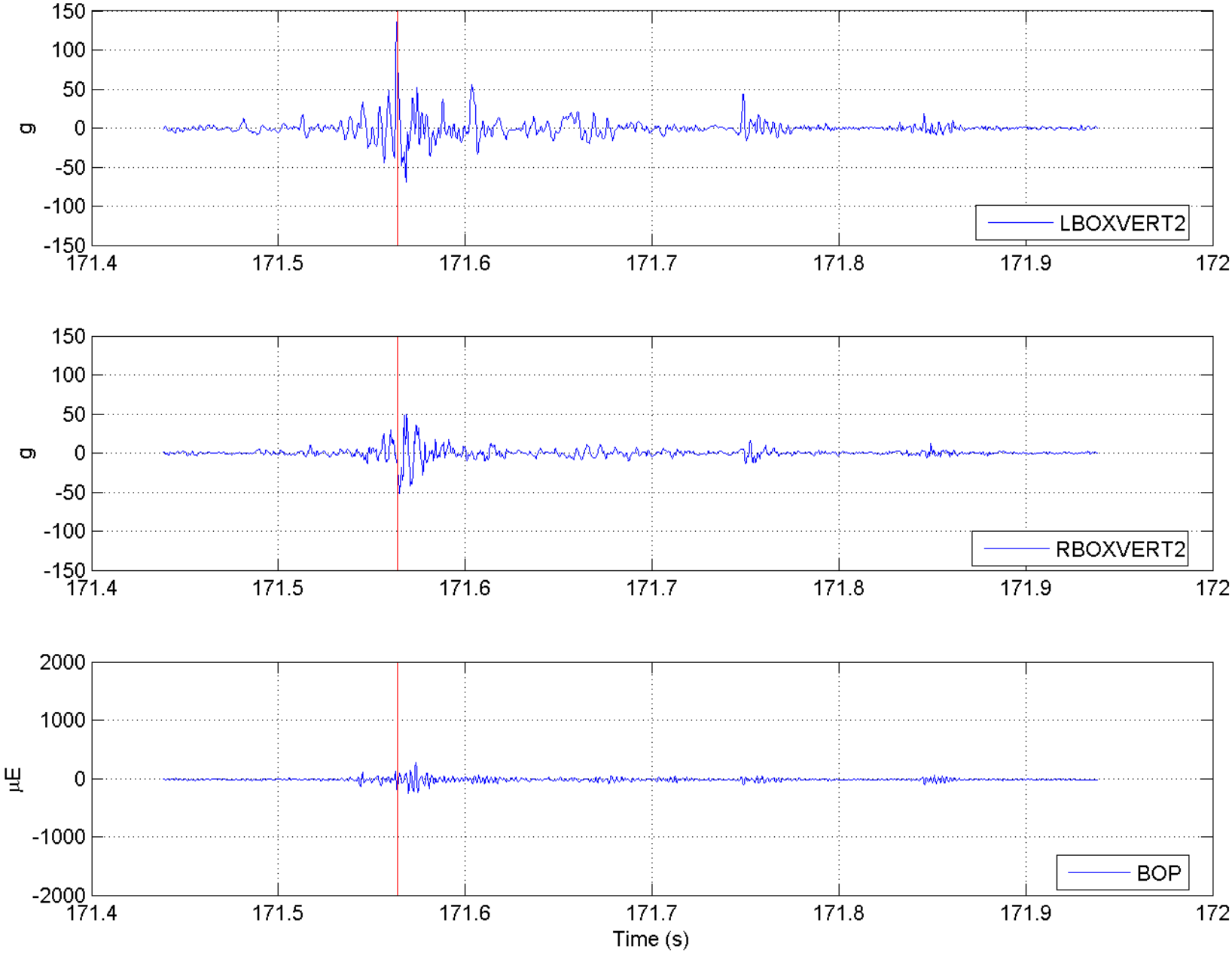
File 061805_14.AB3, Location 953.1393 s, LBOXVERT2 = 129.3 g, RBOXVERT2 = 32.65 g, BOP = 265 uE, Speed = 56.1842 mph, Brake Pressure = 0.352



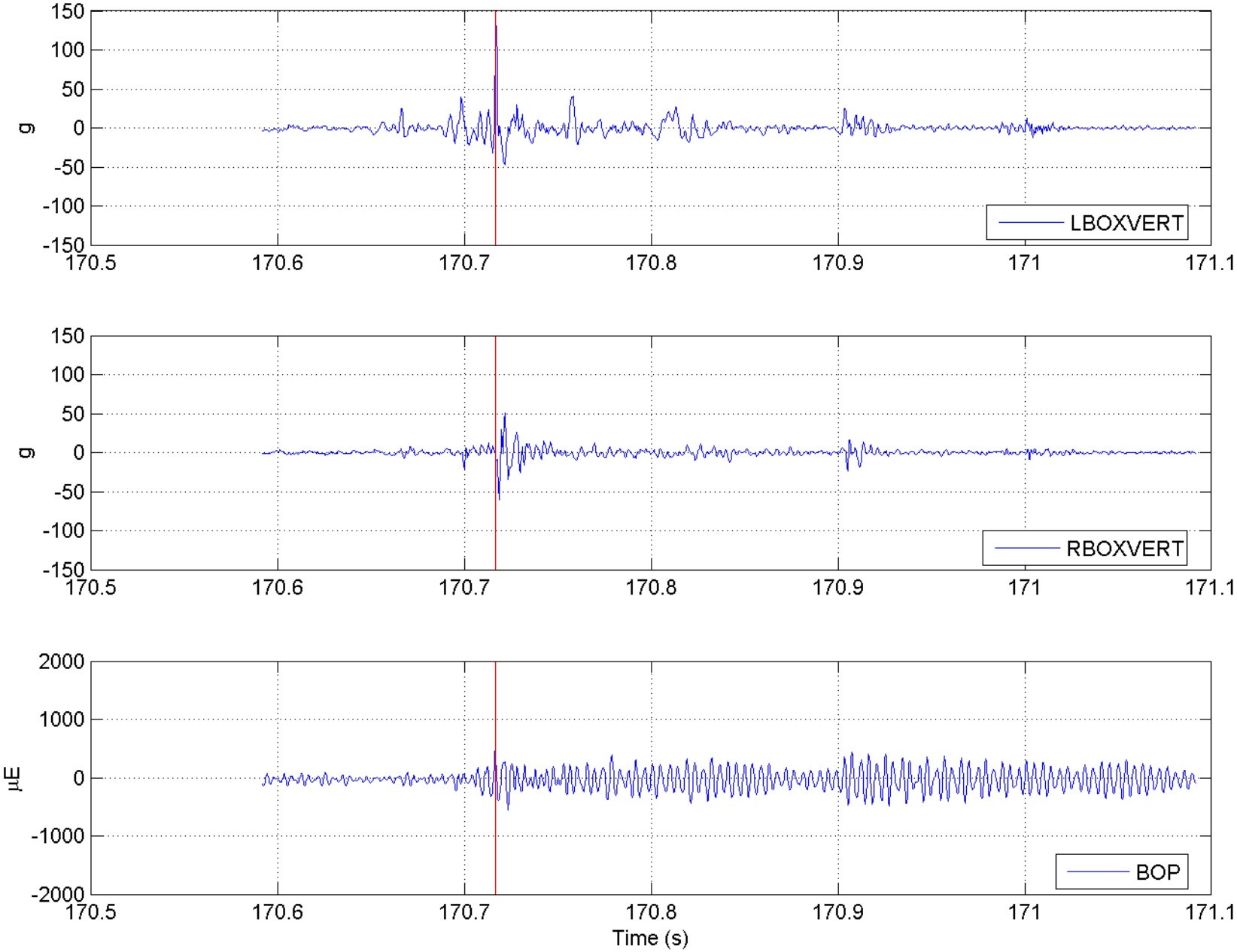
File 061805_14.AB3, Location 891.7777 s, LBOXVERT = 38.12 g, RBOXVERT = 114.78 g, BOP = 669 uE, Speed = 48.896 mph, Brake Pressure = 0.3436



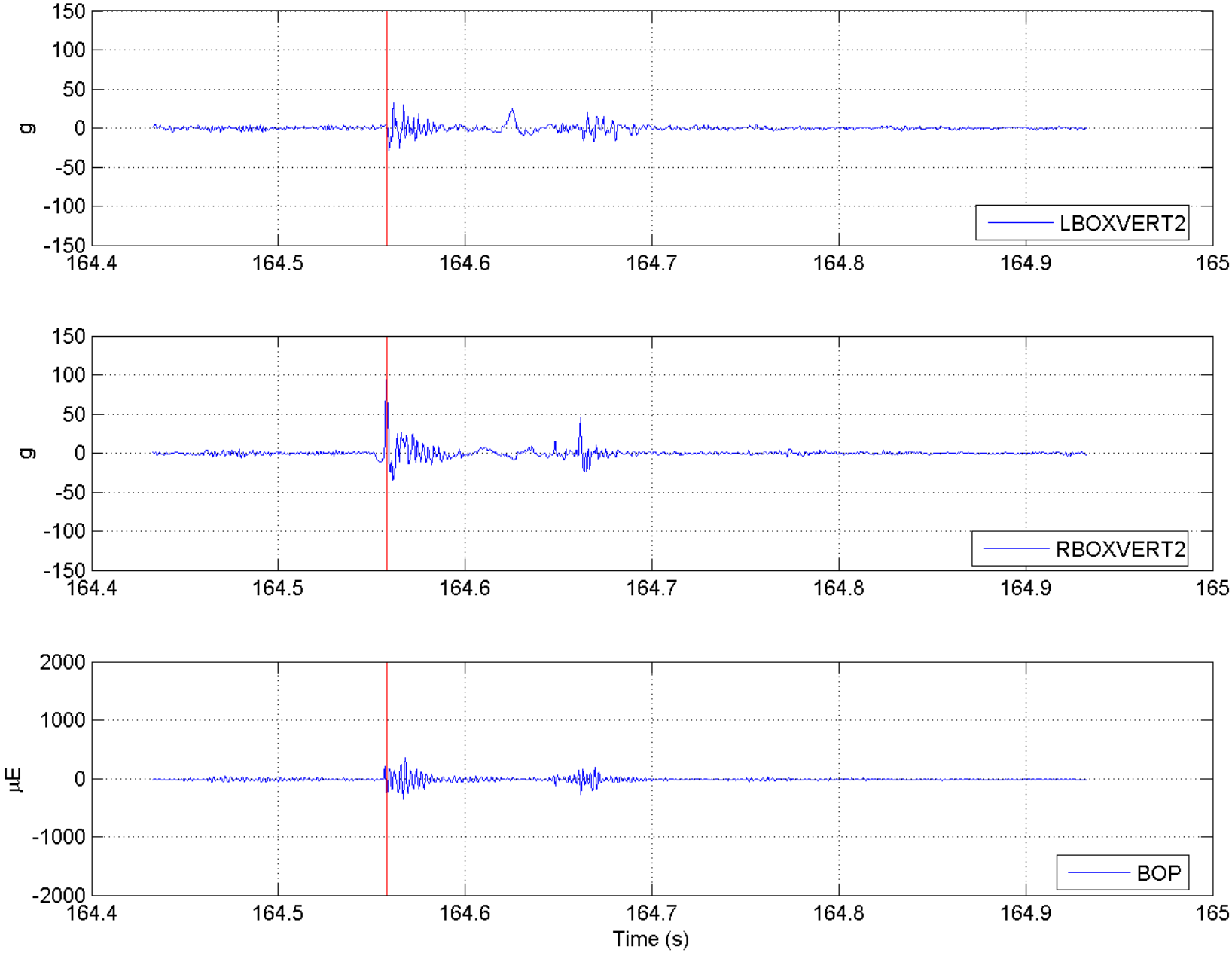
le 061805_15.AB3, Location 171.5637 s, LBOXVERT2 = 138.44 g, RBOXVERT2 = 52.09 g, BOP = 268.5 uE, Speed = 70.7338 mph, Brake Pressure = 0.35



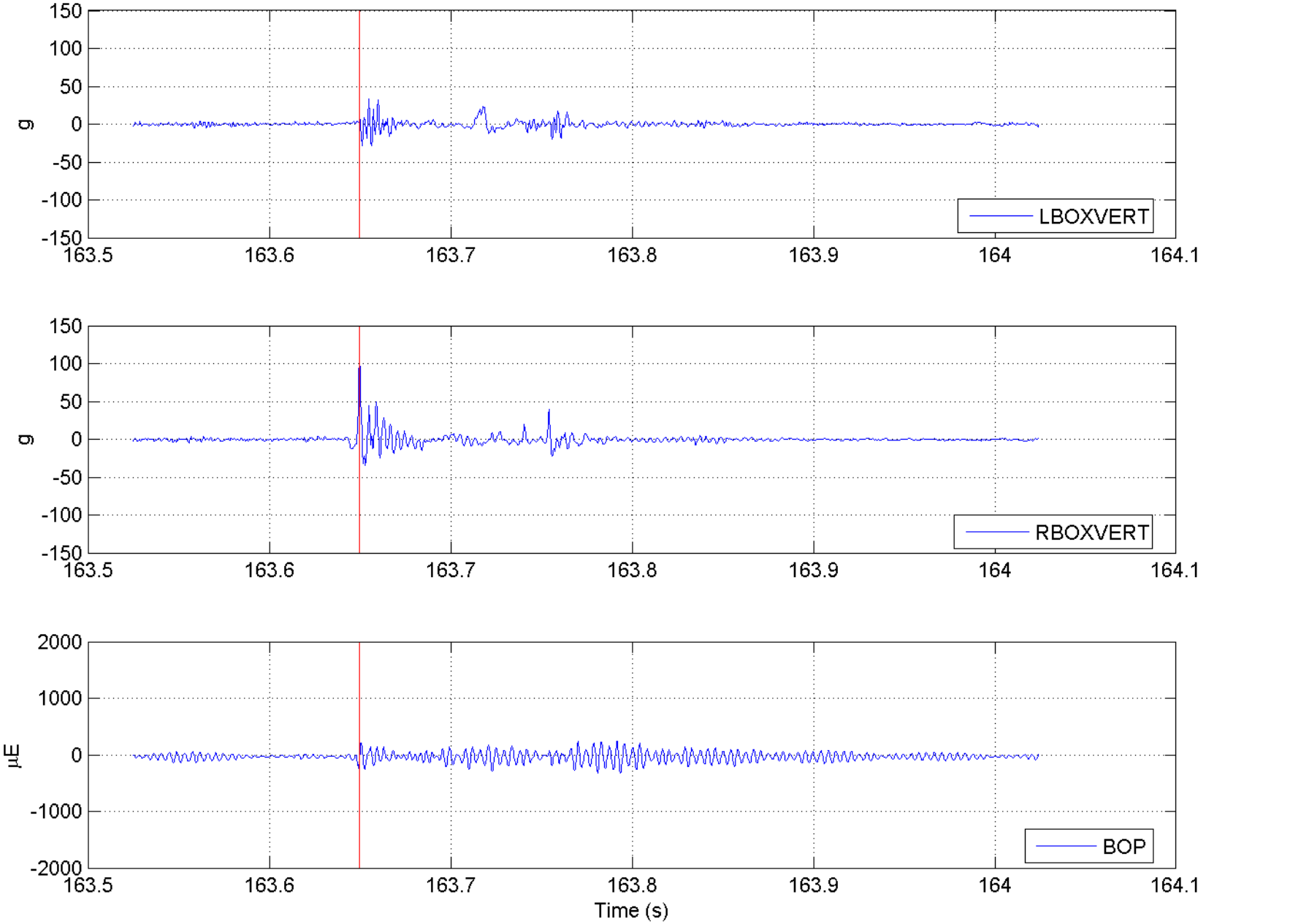
File 061805_15.AB3, Location 170.7167 s, LBOXVERT = 132.72 g, RBOXVERT = 60.04 g, BOP = 545.5 uE, Speed = 70.1936 mph, Brake Pressure = 0.353



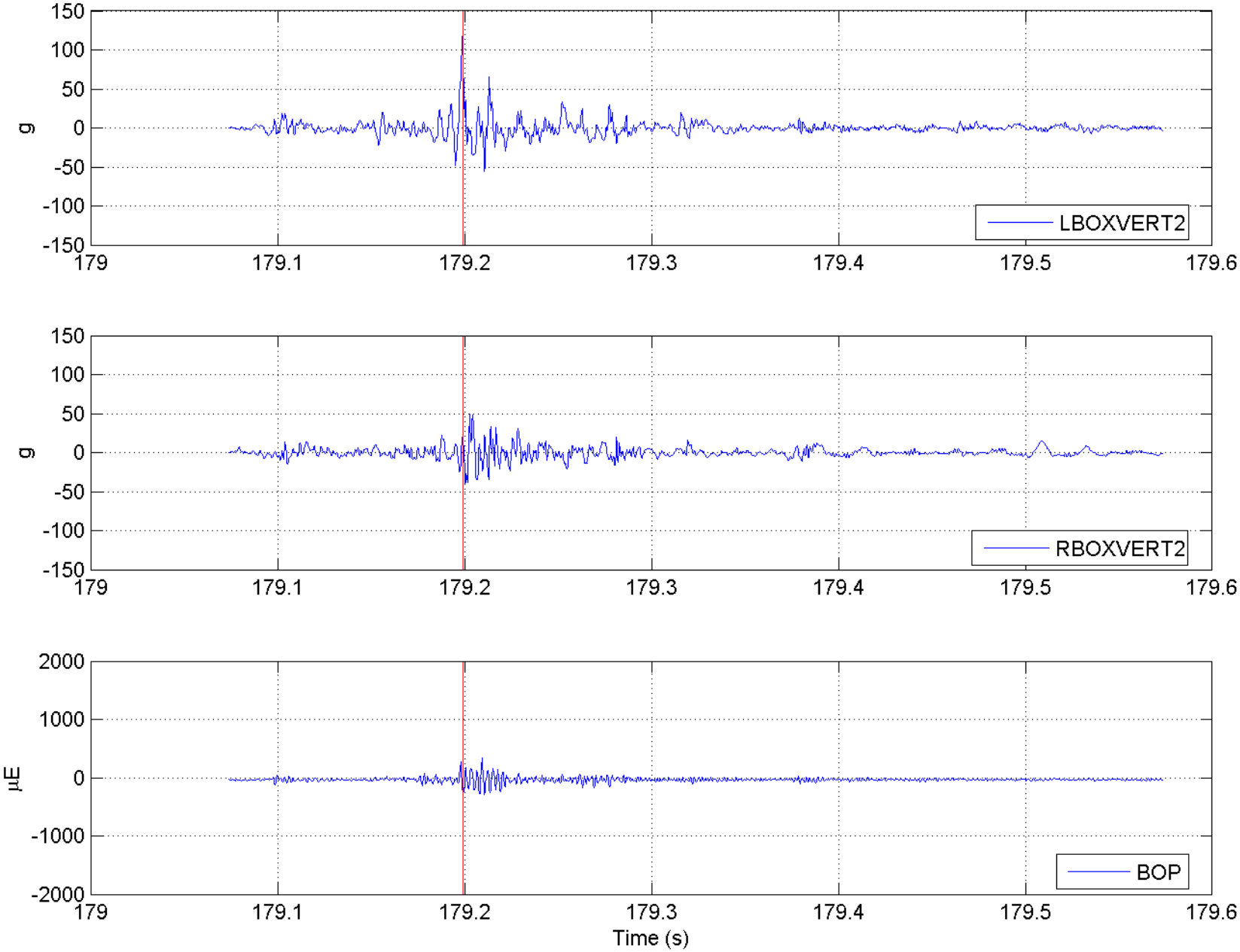
ile 061805_15.AB3, Location 164.558 s, LBOXVERT2 = 31.83 g, RBOXVERT2 = 102.99 g, BOP = 353.5 uE, Speed = 66.0806 mph, Brake Pressure = 0.34



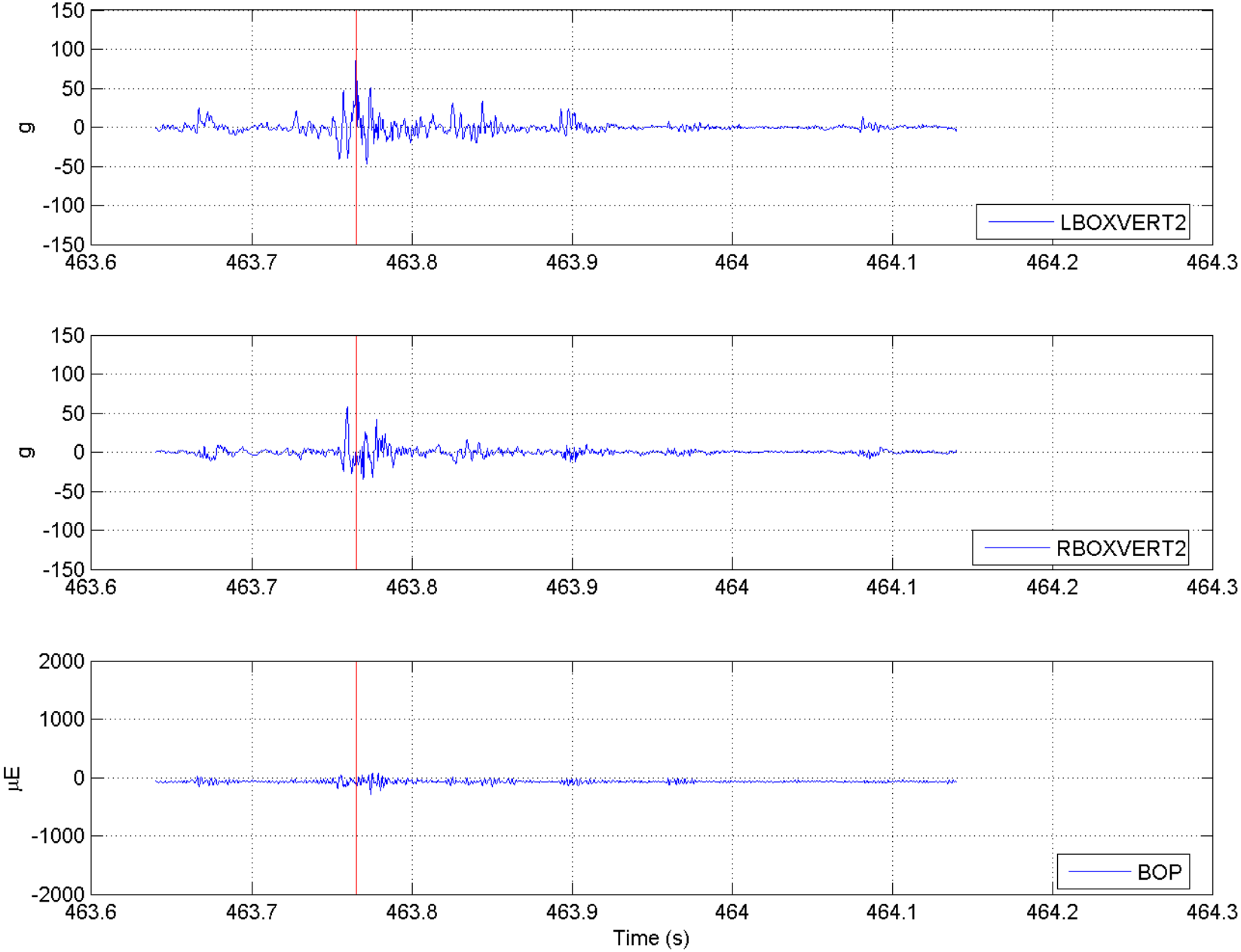
File 061805_15.AB3, Location 163.6493 s, LBOXVERT = 33.95 g, RBOXVERT = 104.49 g, BOP = 320 uE, Speed = 65.3481 mph, Brake Pressure = 0.3630



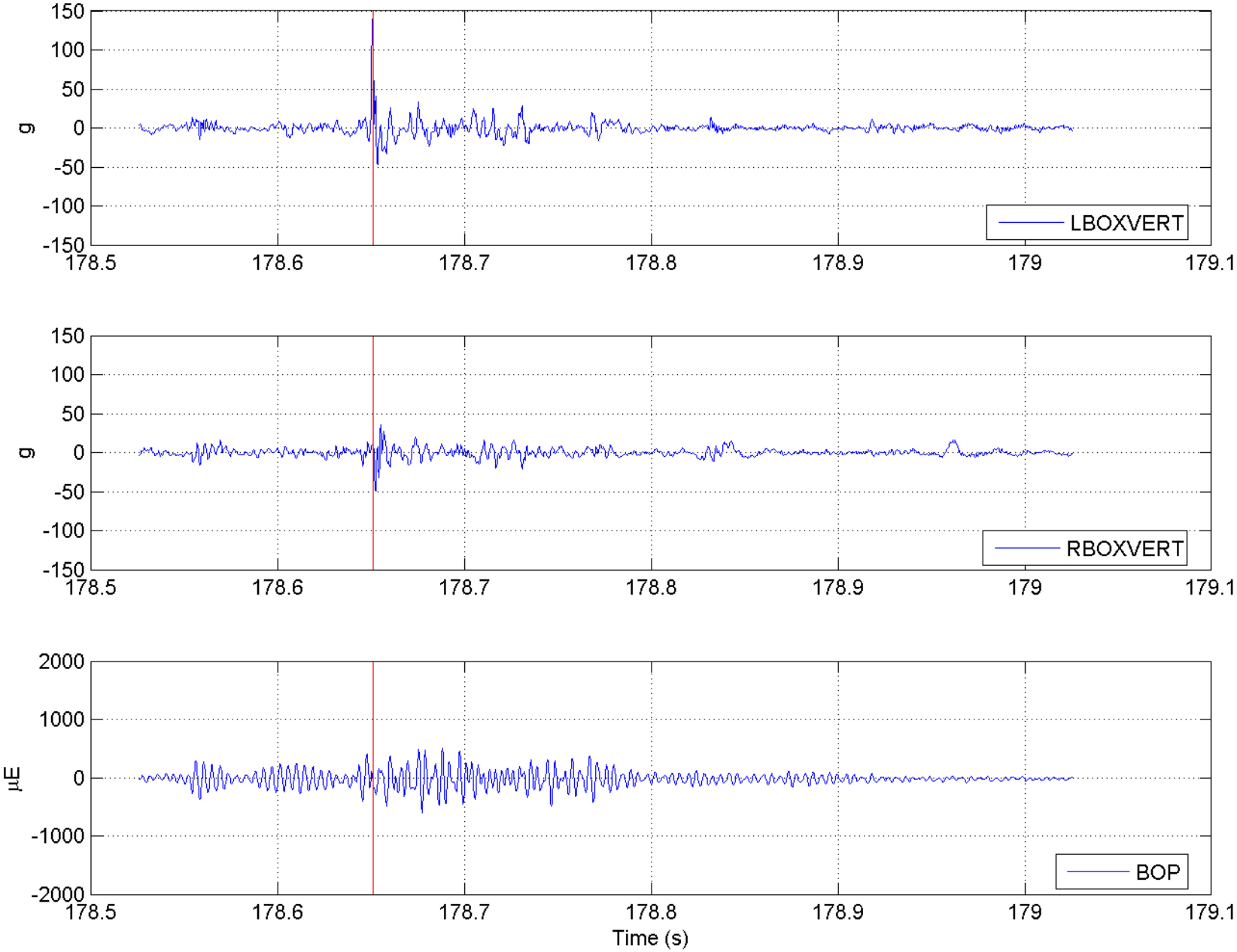
e 061805_22.AB3, Location 179.1987 s, LBOXVERT2 = 127.31 g, RBOXVERT2 = 49.87 g, BOP = 332.5 uE, Speed = 108.9216 mph, Brake Pressure = 0.40



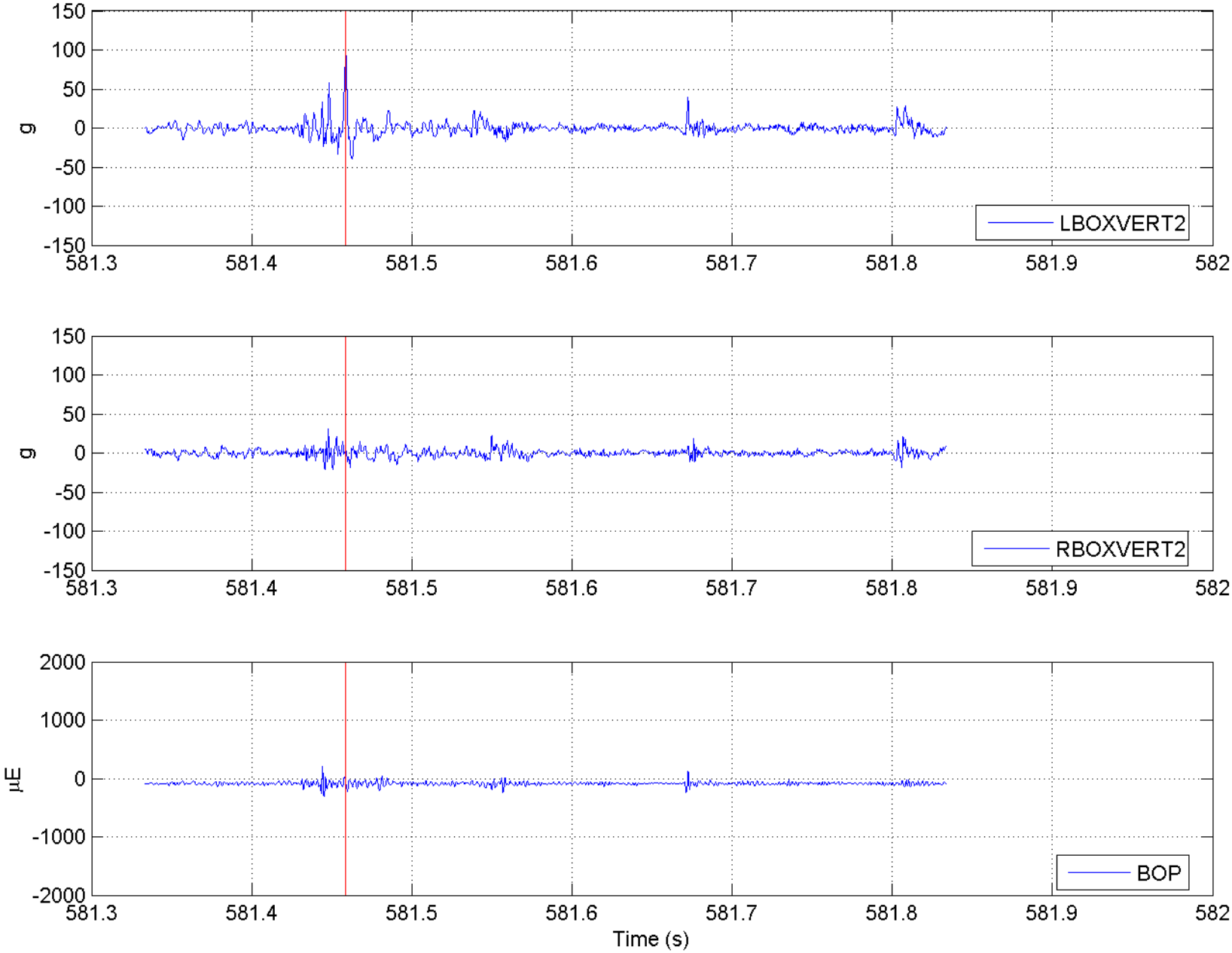
e 061805_22.AB3, Location 463.765 s, LBOXVERT2 = 102.85 g, RBOXVERT2 = 58.44 g, BOP = 282.5 uE, Speed = 103.0225 mph, Brake Pressure = 0.41



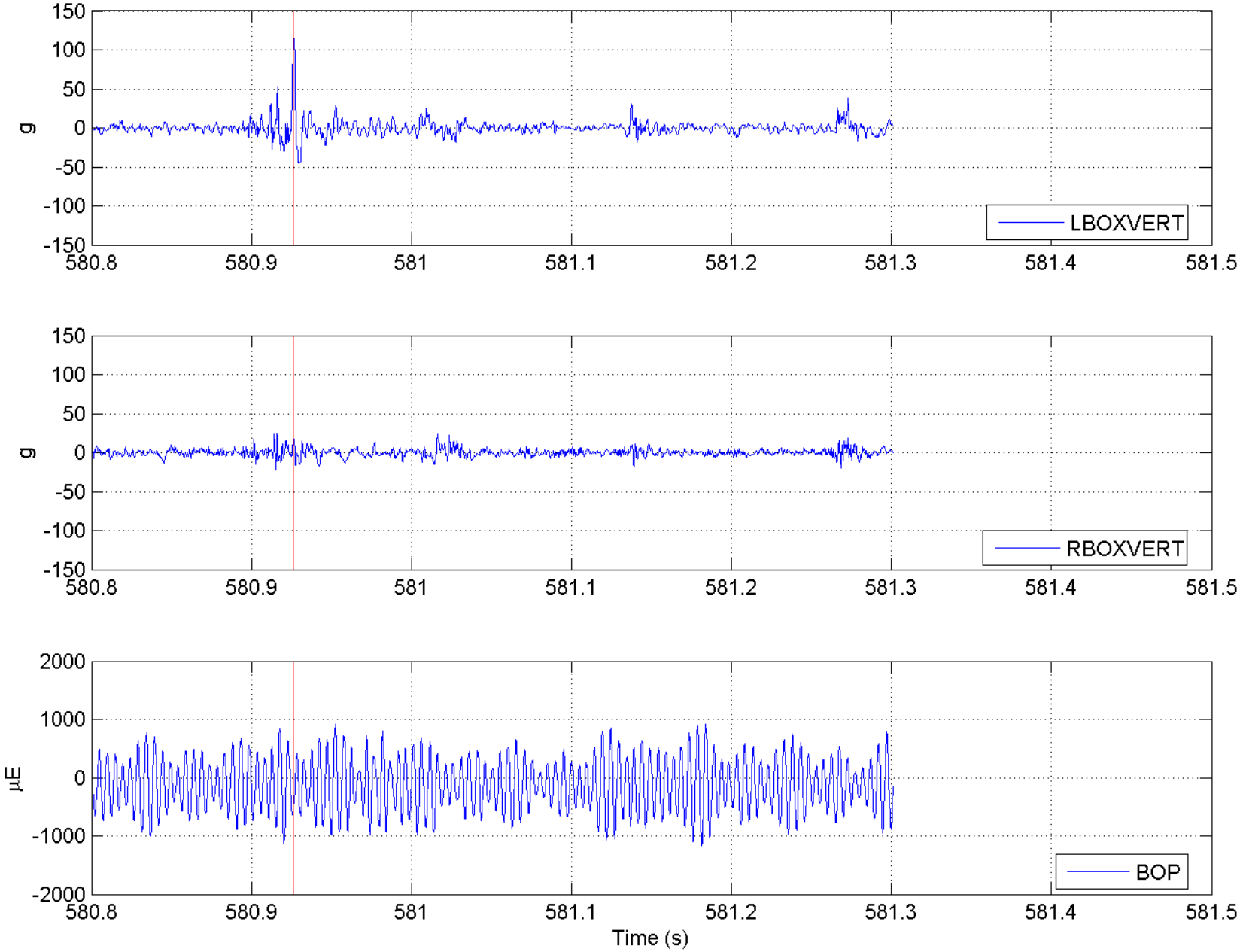
File 061805_22.AB3, Location 178.6507 s, LBOXVERT = 147.13 g, RBOXVERT = 49.33 g, BOP = 600.5 uE, Speed = 108.8838 mph, Brake Pressure = 0.39



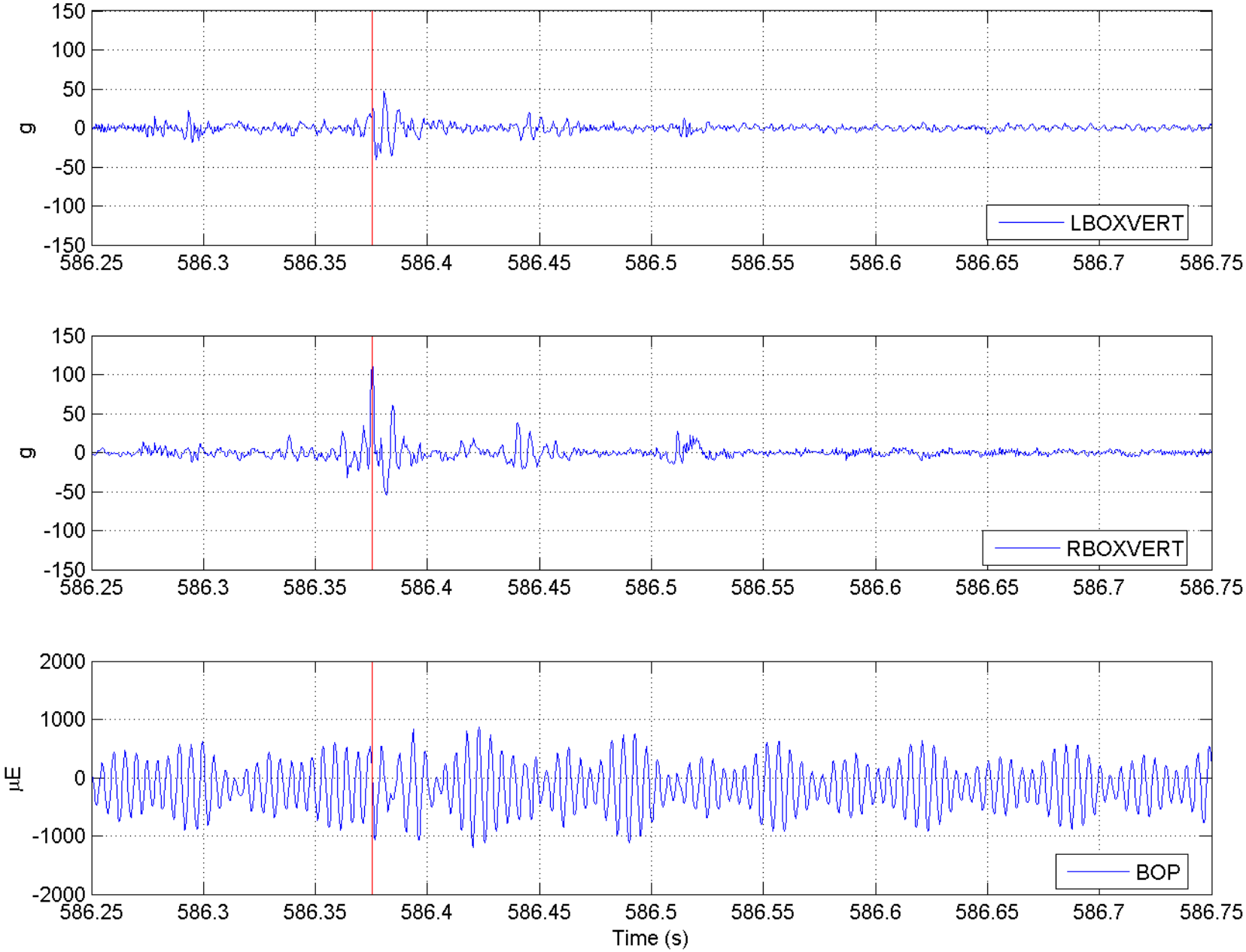
le 061805_24.AB3, Location 581.4587 s, LBOXVERT2 = 102.97 g, RBOXVERT2 = 31.46 g, BOP = 303 uE, Speed = 110.9689 mph, Brake Pressure = 56.0



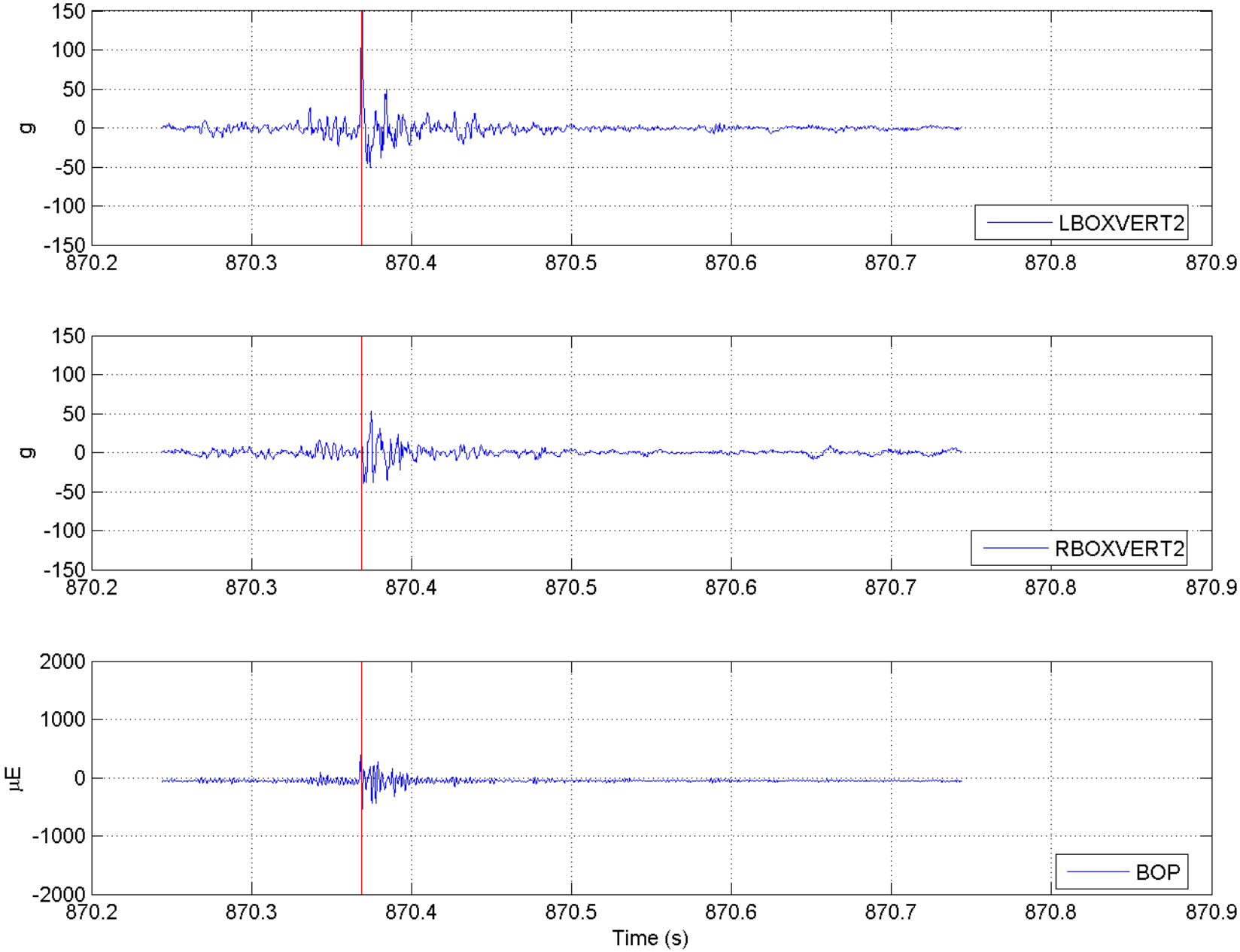
le 061805_24.AB3, Location 580.9263 s, LBOXVERT = 117.28 g, RBOXVERT = 25.15 g, BOP = 1167.5 uE, Speed = 112.2604 mph, Brake Pressure = 55.9



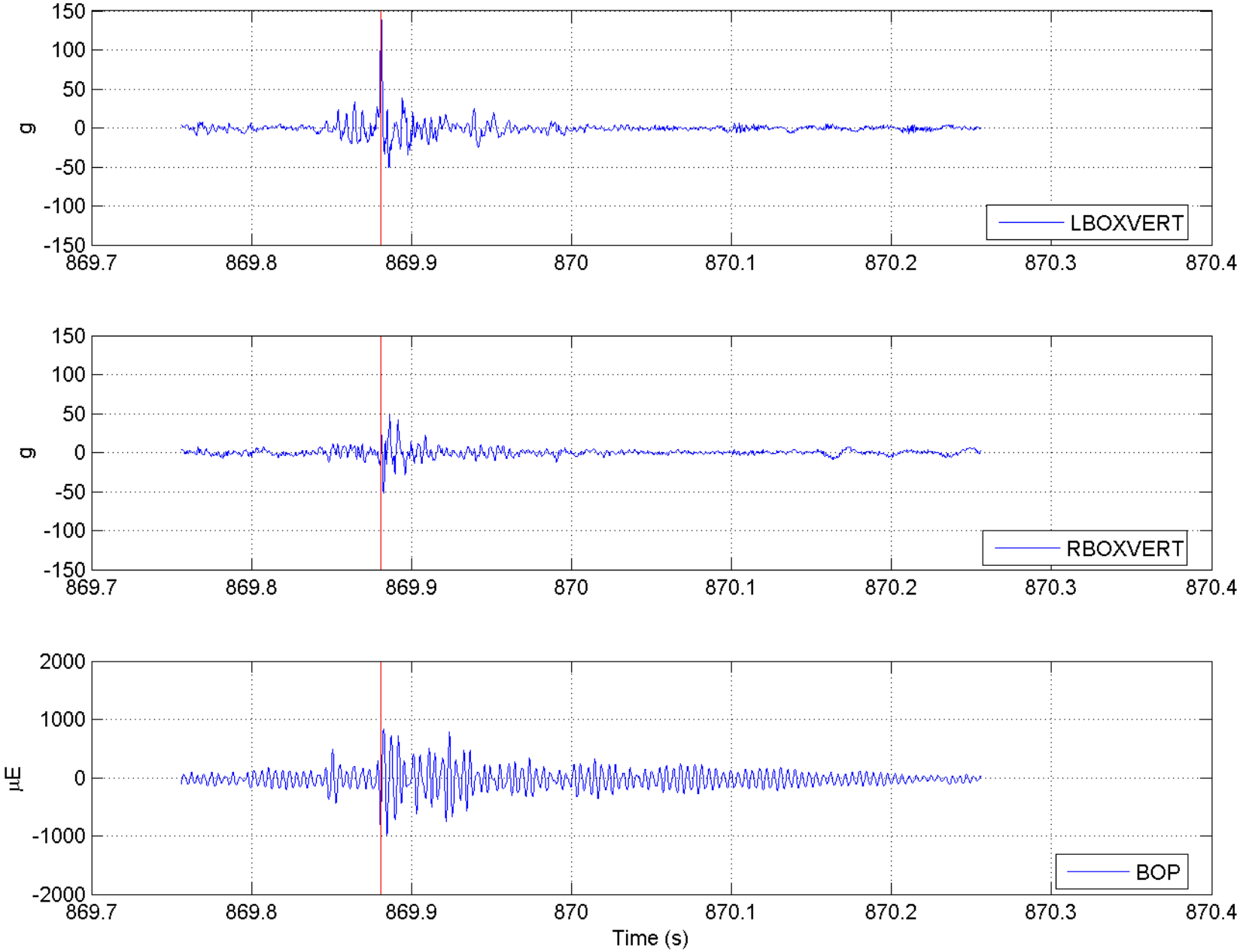
File 061805_24.AB3, Location 586.3753 s, LBOXVERT = 47.5 g, RBOXVERT = 115.75 g, BOP = 1202 uE, Speed = 98.6699 mph, Brake Pressure = 55.732



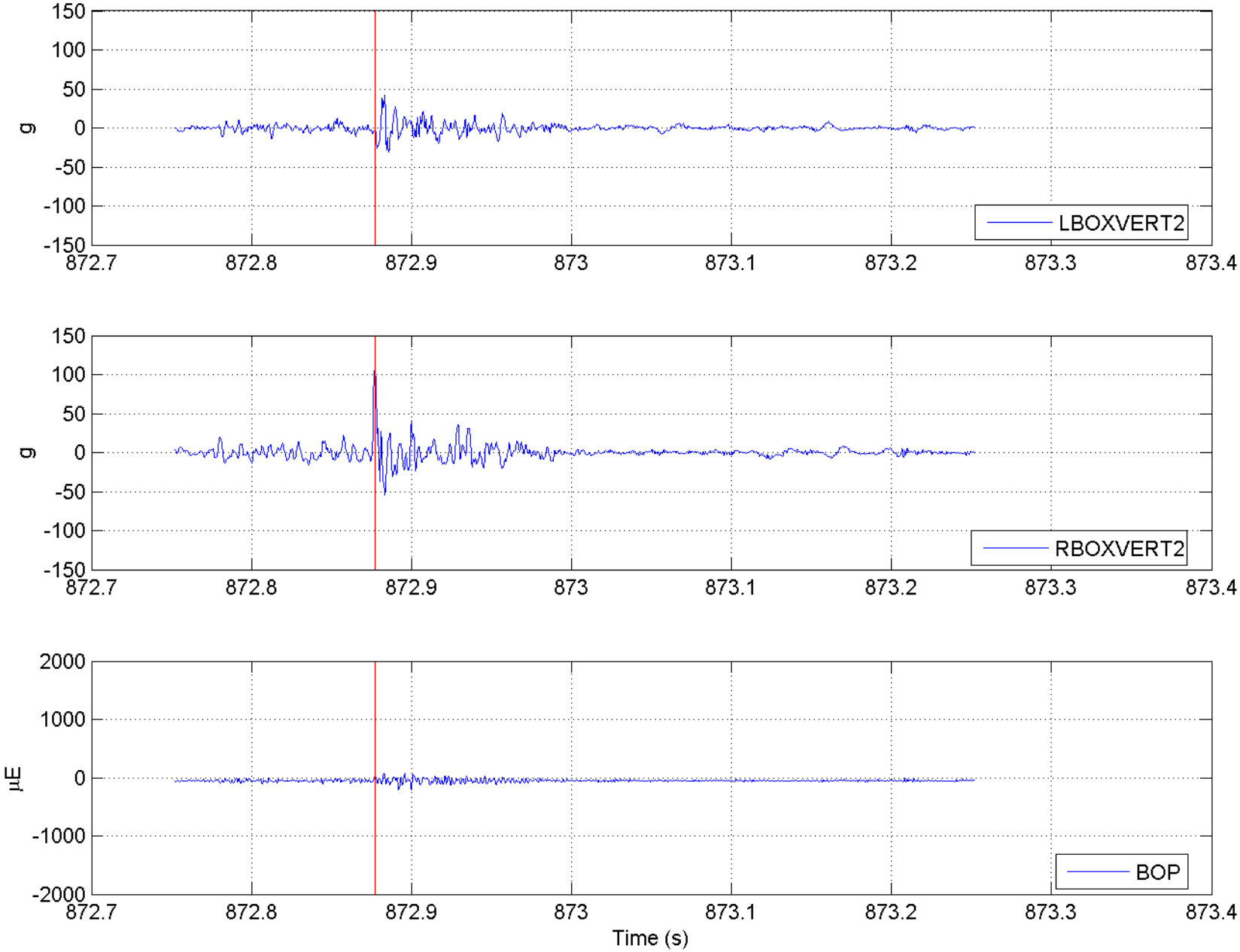
File 061805_25.AB3, Location 870.369 s, LBOXVERT2 = 163.38 g, RBOXVERT2 = 53.69 g, BOP = 544 uE, Speed = 122.01 mph, Brake Pressure = 0.4029



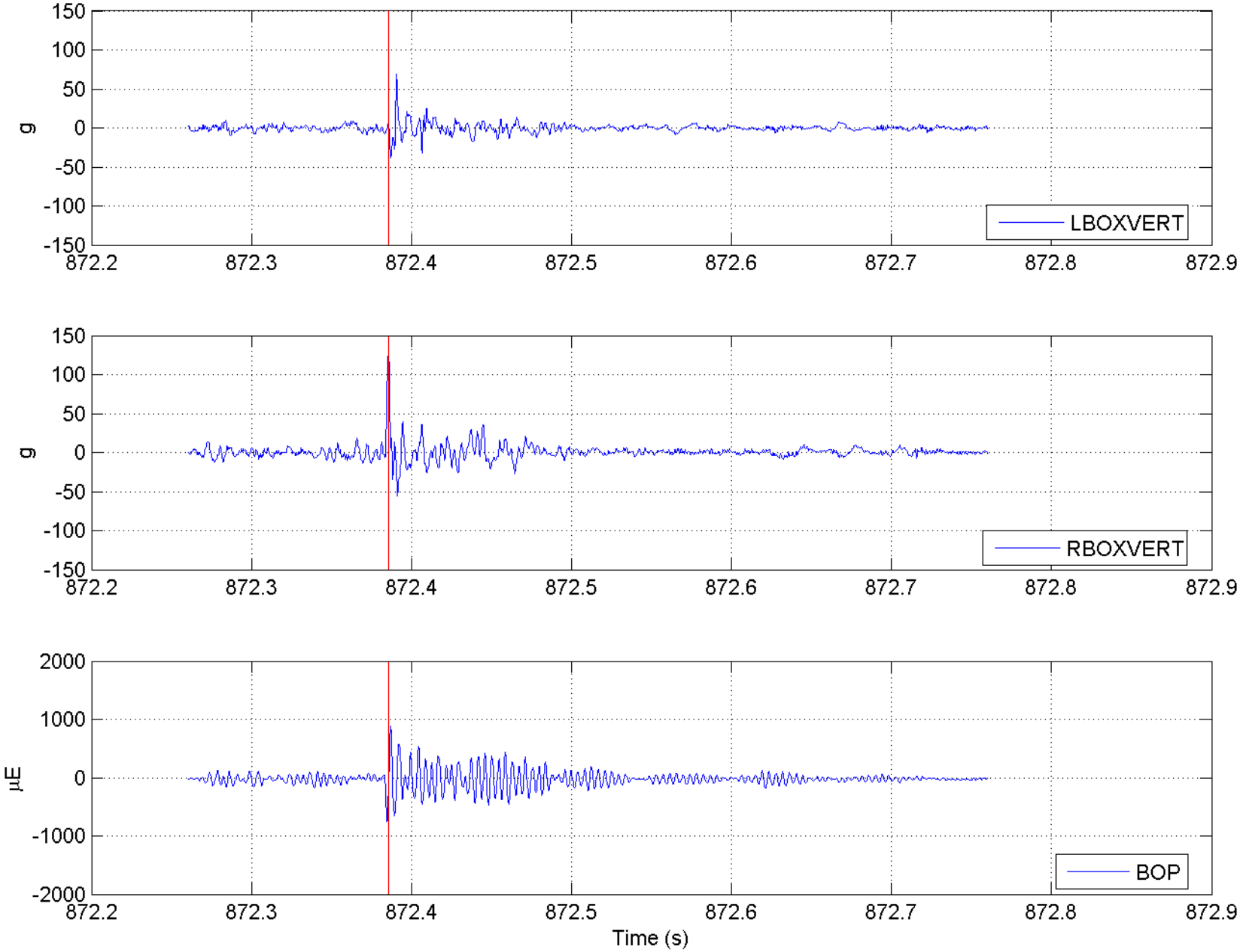
File 061805_25.AB3, Location 869.881 s, LBOXVERT = 154.69 g, RBOXVERT = 51.5 g, BOP = 978 uE, Speed = 122.1021 mph, Brake Pressure = 0.4027



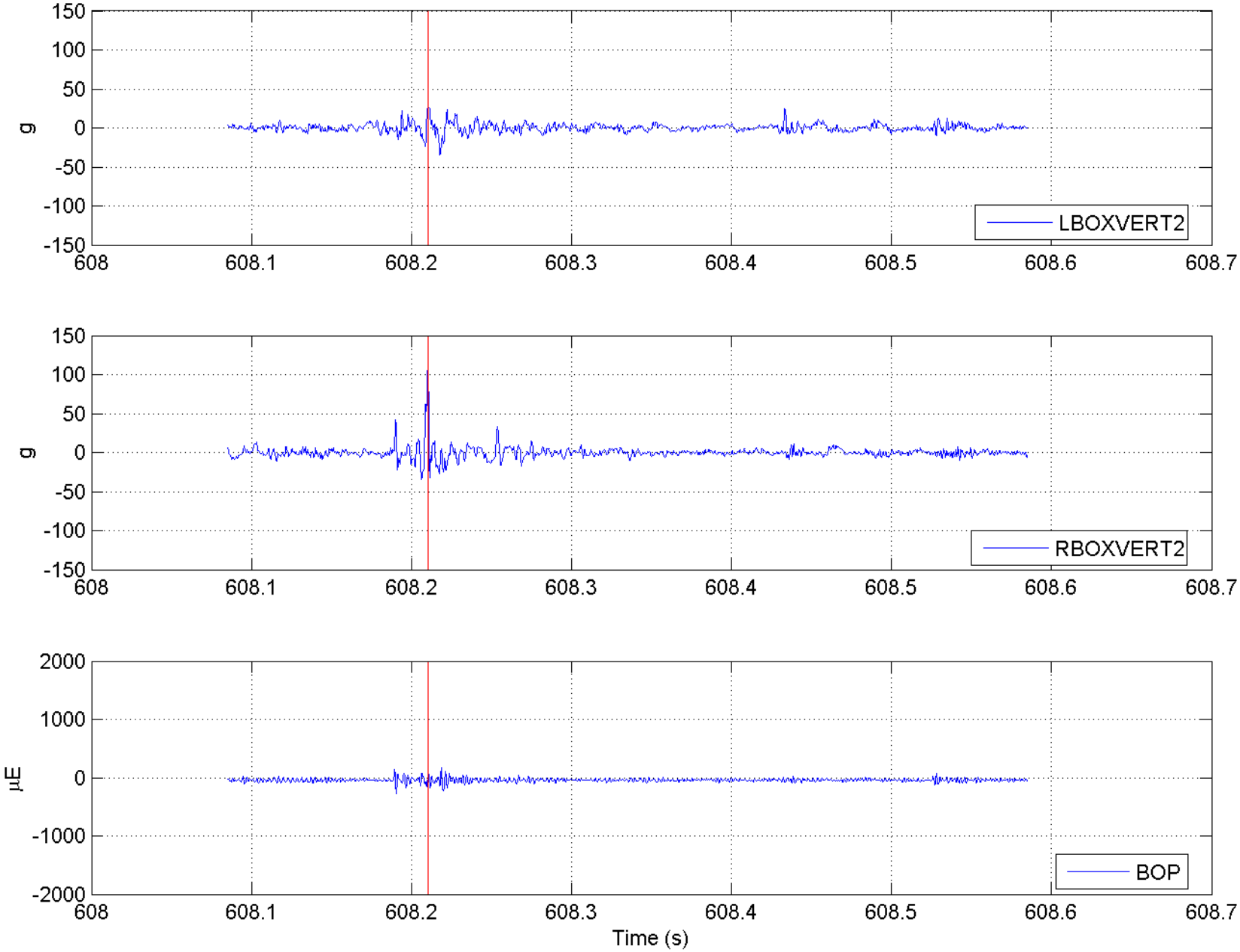
le 061805_25.AB3, Location 872.877 s, LBOXVERT2 = 42.08 g, RBOXVERT2 = 110.34 g, BOP = 211.5 uE, Speed = 121.2186 mph, Brake Pressure = 0.40



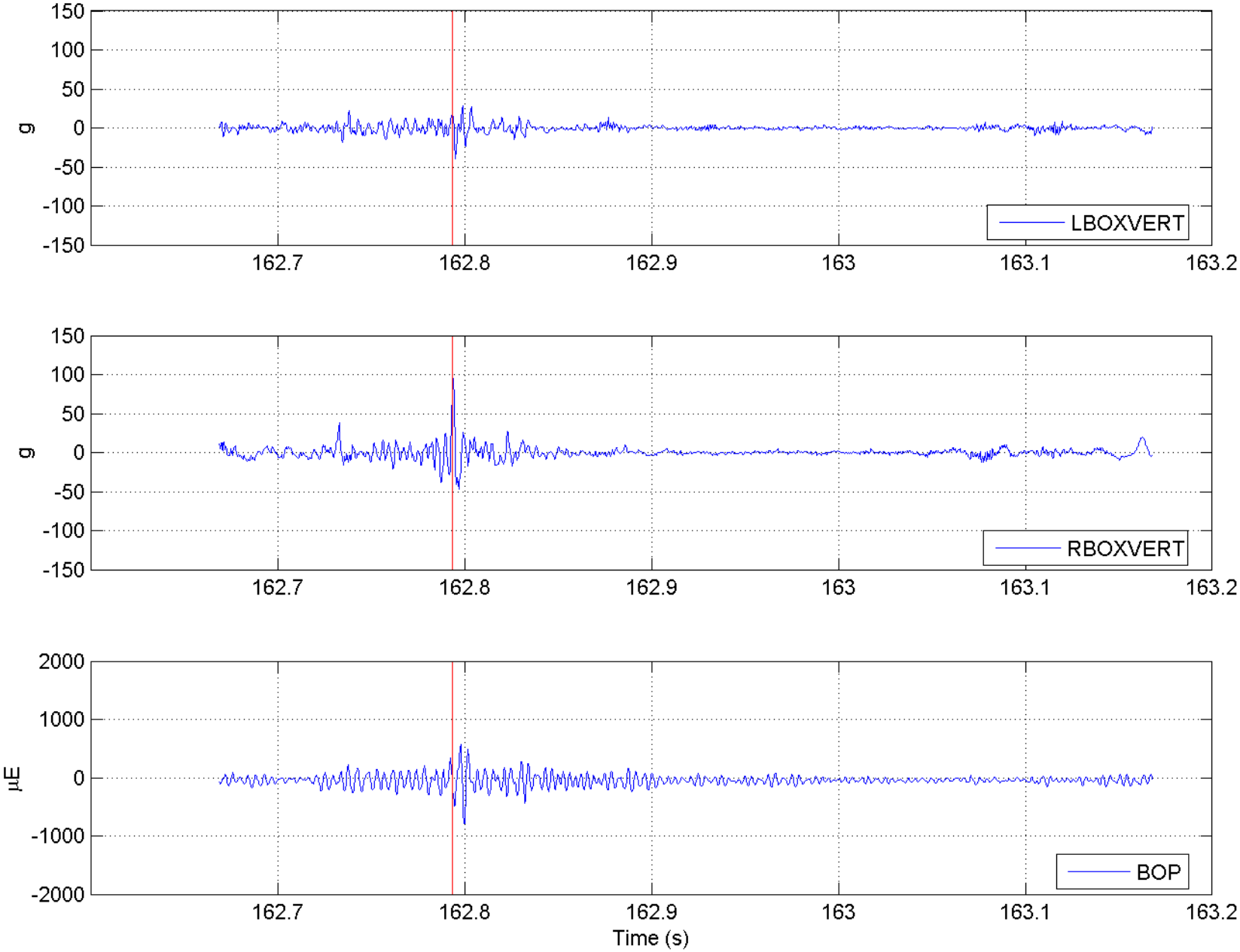
File 061805_25.AB3, Location 872.3857 s, LBOXVERT = 68.91 g, RBOXVERT = 127.77 g, BOP = 879 uE, Speed = 121.2911 mph, Brake Pressure = 0.407



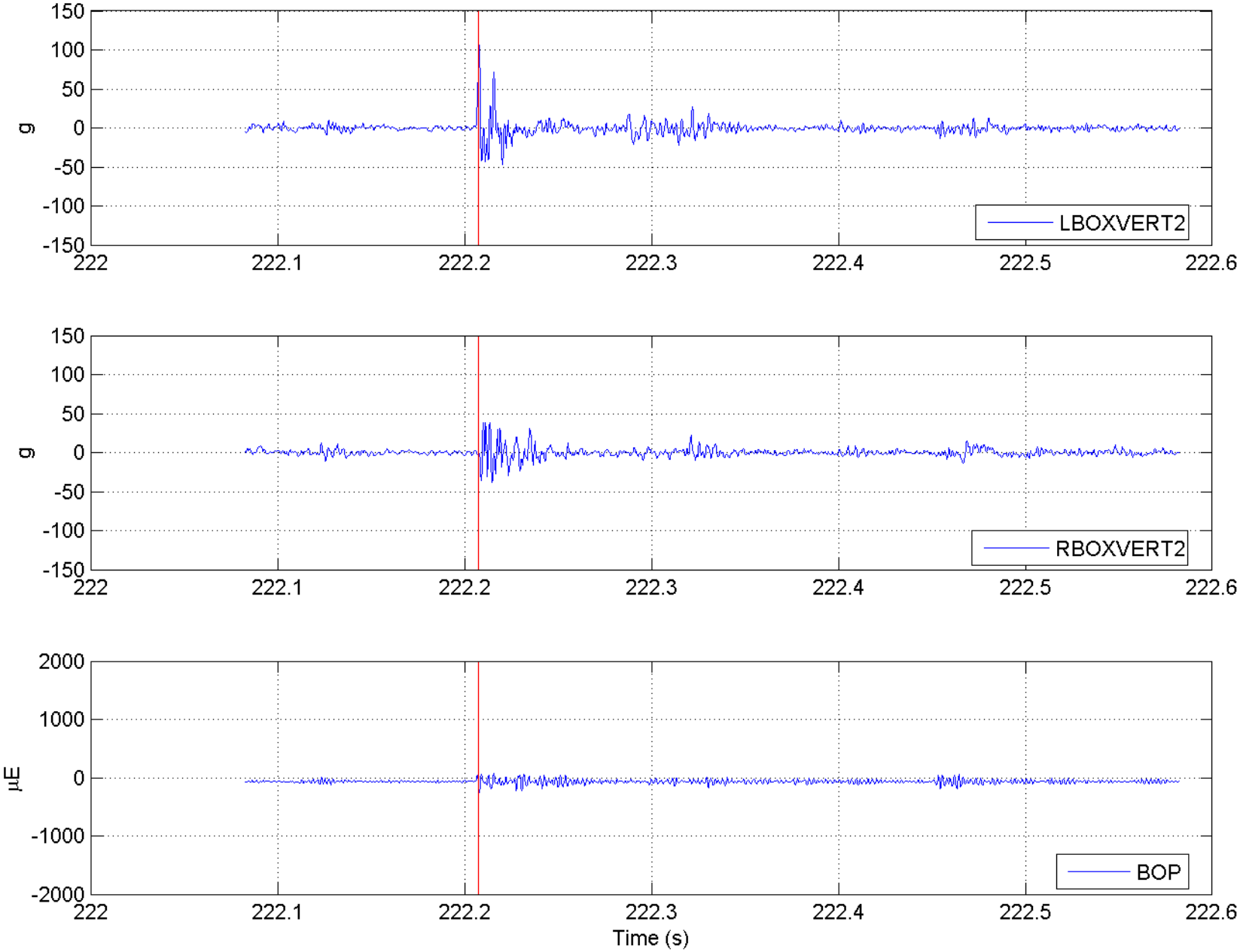
le 061805_28.AB3, Location 608.2103 s, LBOXVERT2 = 35.17 g, RBOXVERT2 = 107.62 g, BOP = 275 uE, Speed = 125.6544 mph, Brake Pressure = 0.40



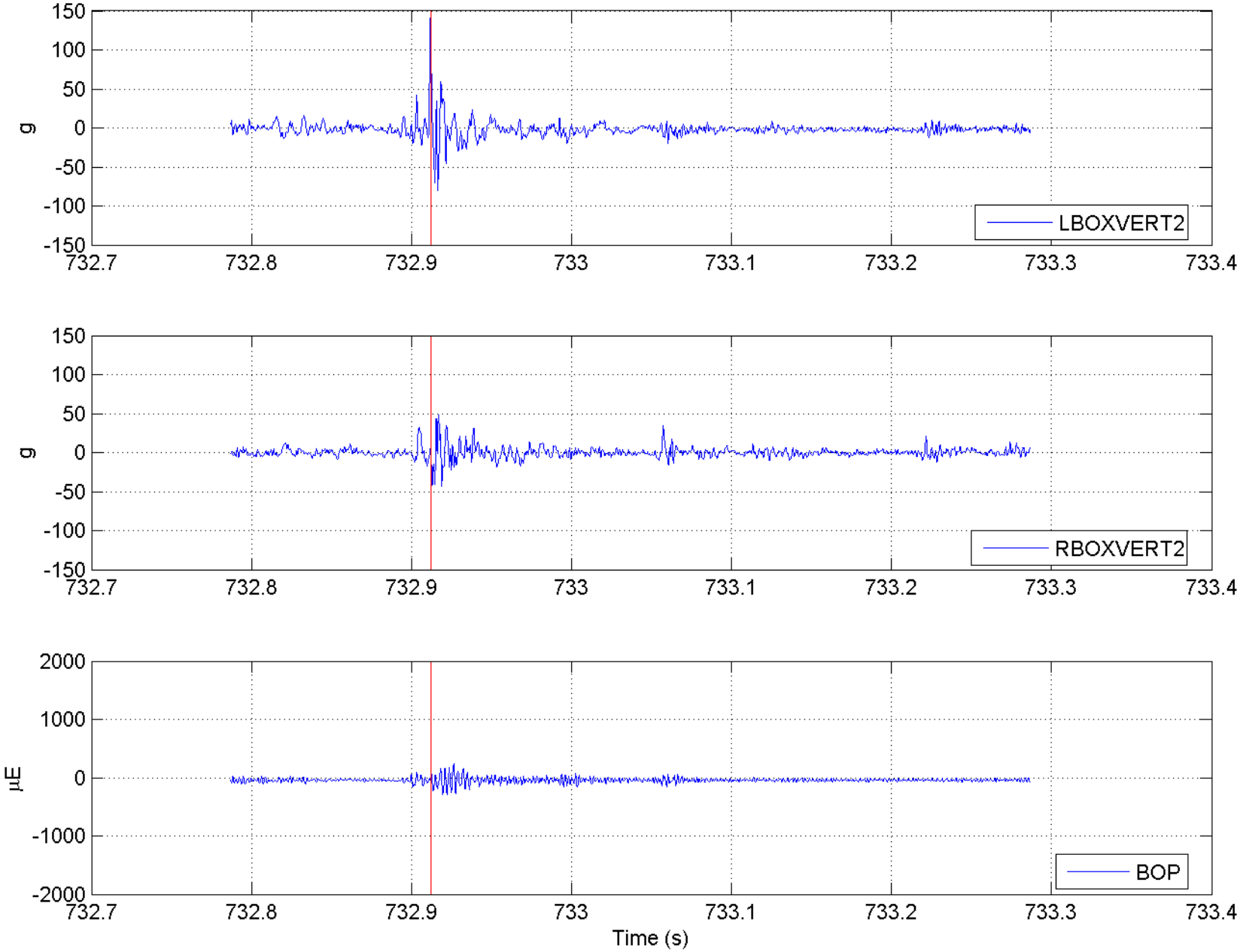
File 061805_29.AB3, Location 162.7933 s, LBOXVERT = 38.96 g, RBOXVERT = 100.4 g, BOP = 792 uE, Speed = 118.1039 mph, Brake Pressure = 0.4078



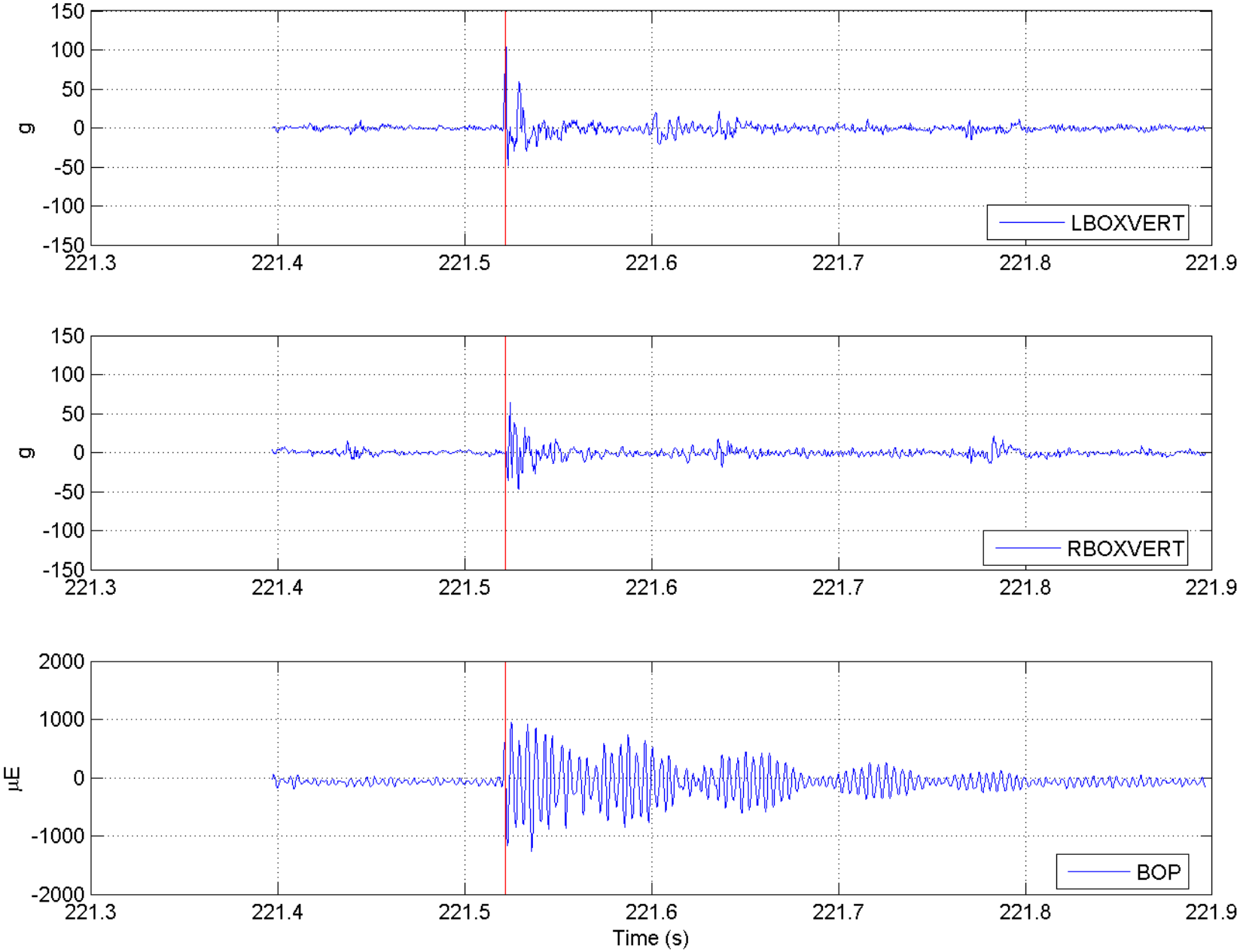
e 061805_30.AB3, Location 222.2073 s, LBOXVERT2 = 110.85 g, RBOXVERT2 = 38.67 g, BOP = 257.5 uE, Speed = 86.9592 mph, Brake Pressure = 0.43



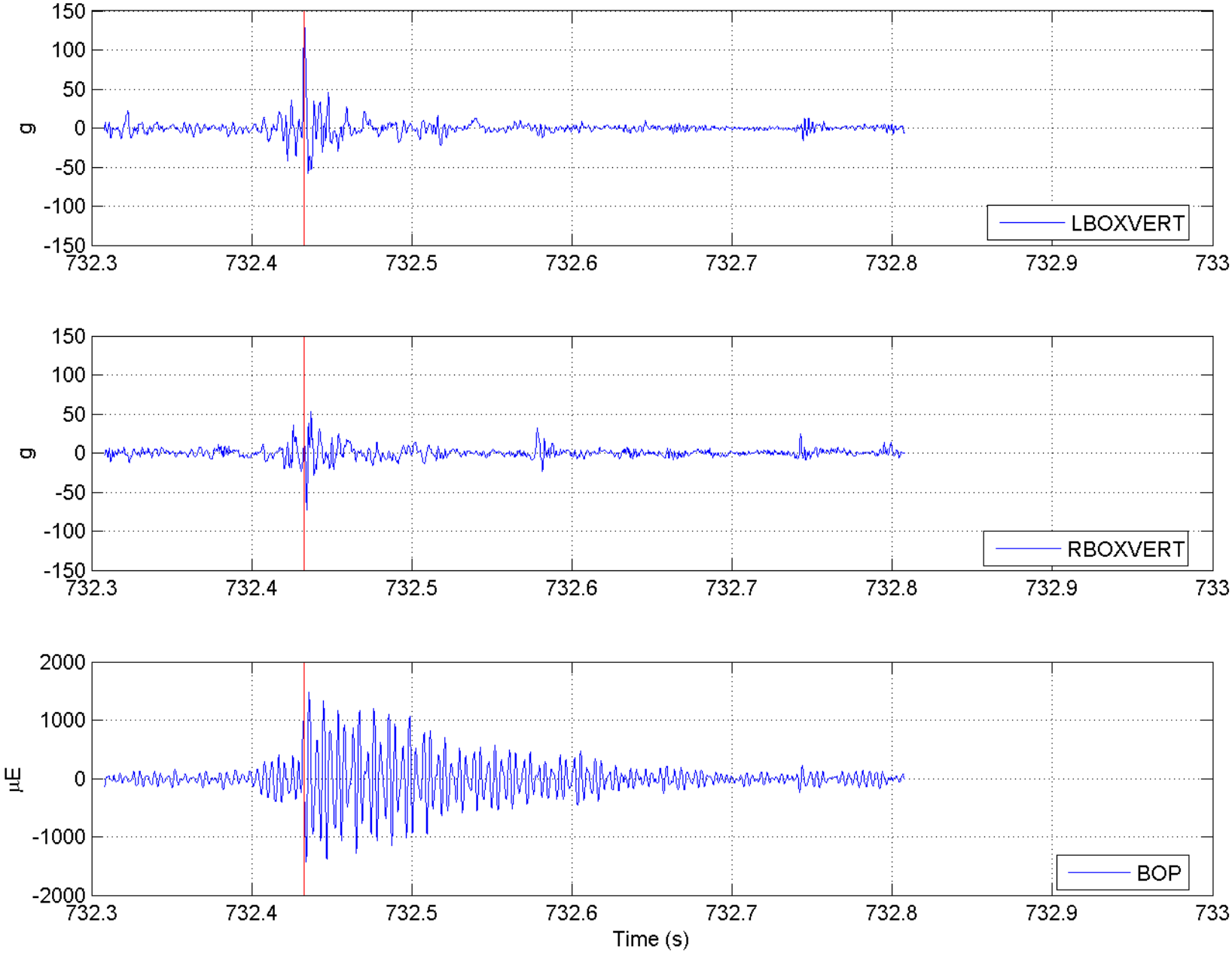
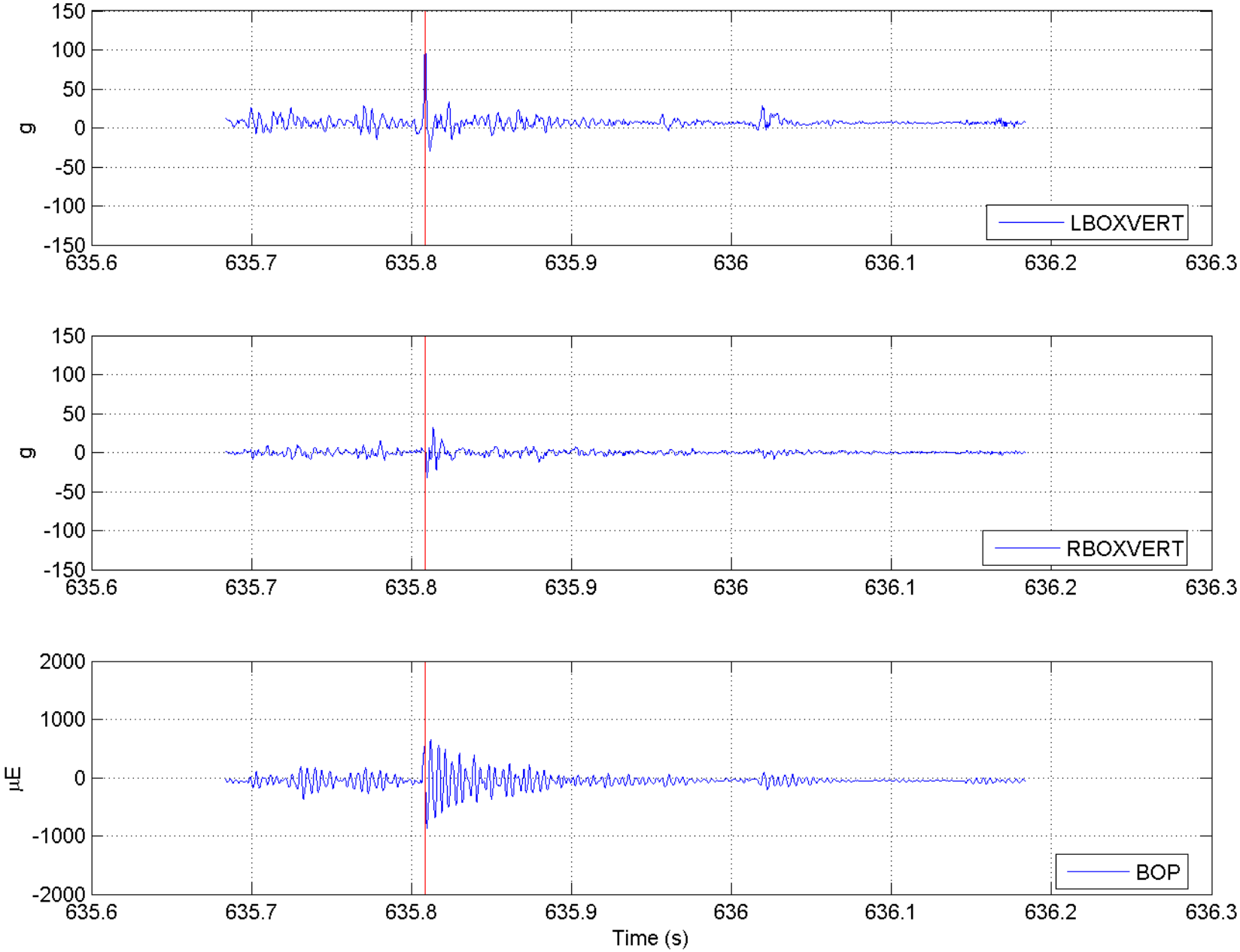
File 061805_30.AB3, Location 732.912 s, LBOXVERT2 = 145.29 g, RBOXVERT2 = 48.61 g, BOP = 290 uE, Speed = 124.4461 mph, Brake Pressure = 0.433



File 061805_30.AB3, Location 221.5217 s, LBOXVERT = 117.23 g, RBOXVERT = 63.93 g, BOP = 1263 uE, Speed = 86.9801 mph, Brake Pressure = 0.433



File 061805_30.AB3, Location 732.433 s, LBOXVERT = 145.75 g, RBOXVERT = 73.05 g, BOP = 1487 uE, Speed = 124.5255 mph, Brake Pressure = 0.439



File 061805_31.AB3, Location 635.8087 s, LBOXVERT = 107.81 g, RBOXVERT = 32.36 g, BOP = 863 uE, Speed = 46.1218 mph, Brake Pressure = 4.664