Consortium for Electric Reliability Technology Solutions

NERC Interconnections Frequency Performance and Trends

NERC Interconnections 2012 Frequency Performance, Frequency Events Characteristics and 5-Year Trends (Preliminary Results)

For: NERC Resources Subcommittee

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Tucson, Arizona, January 23, 2013

Presentation Outline

- Objective, Datasets, and Performance Parameters
- NERC Interconnections 2012 Frequency Performance and 5-Year Trends
- Eastern, Western 2012 Frequency Events Characteristics and 5-Year Trends
  (preliminary results for ERCOT and Hydro Quebec are available)

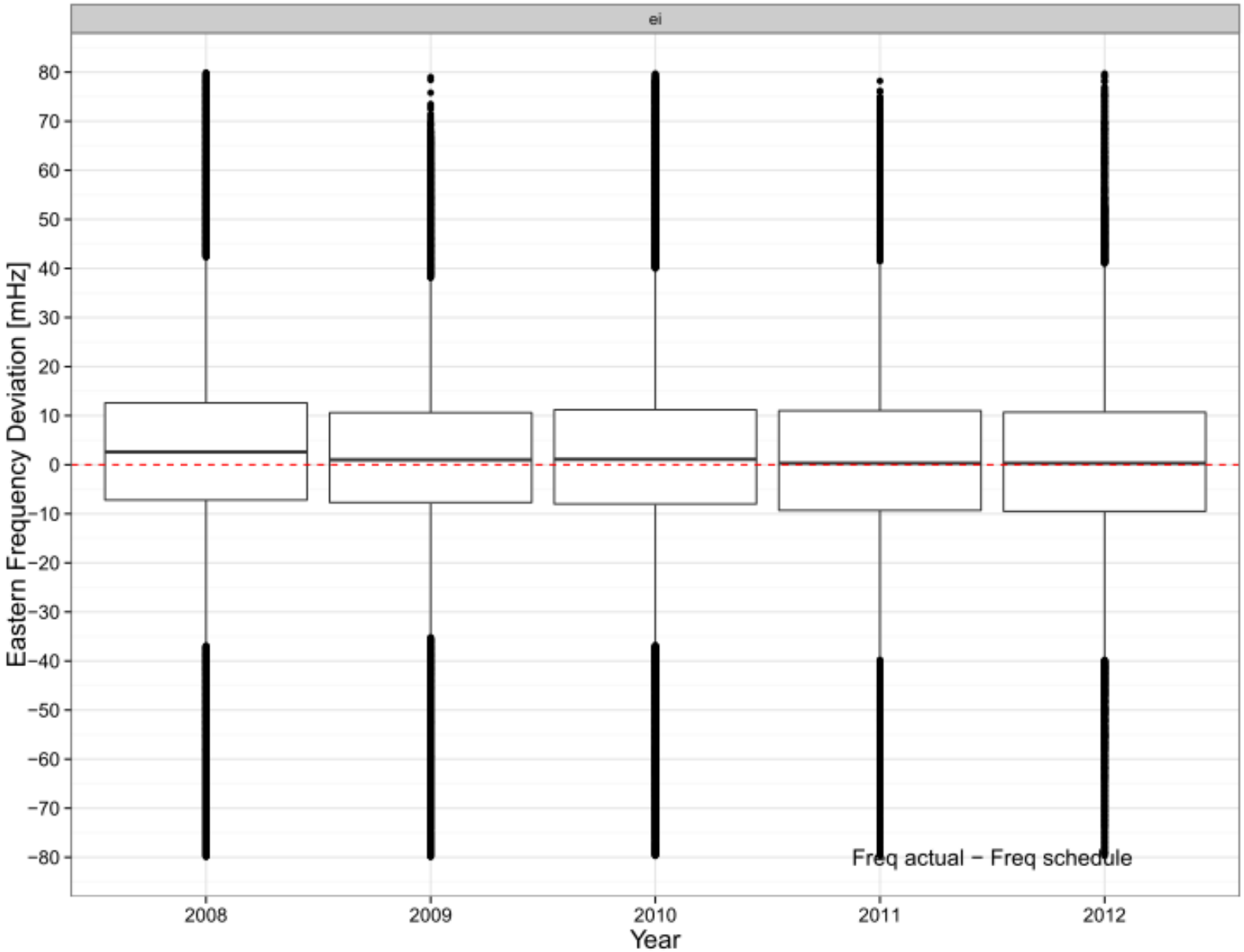
Objective, Data Sets and Performance Parameters

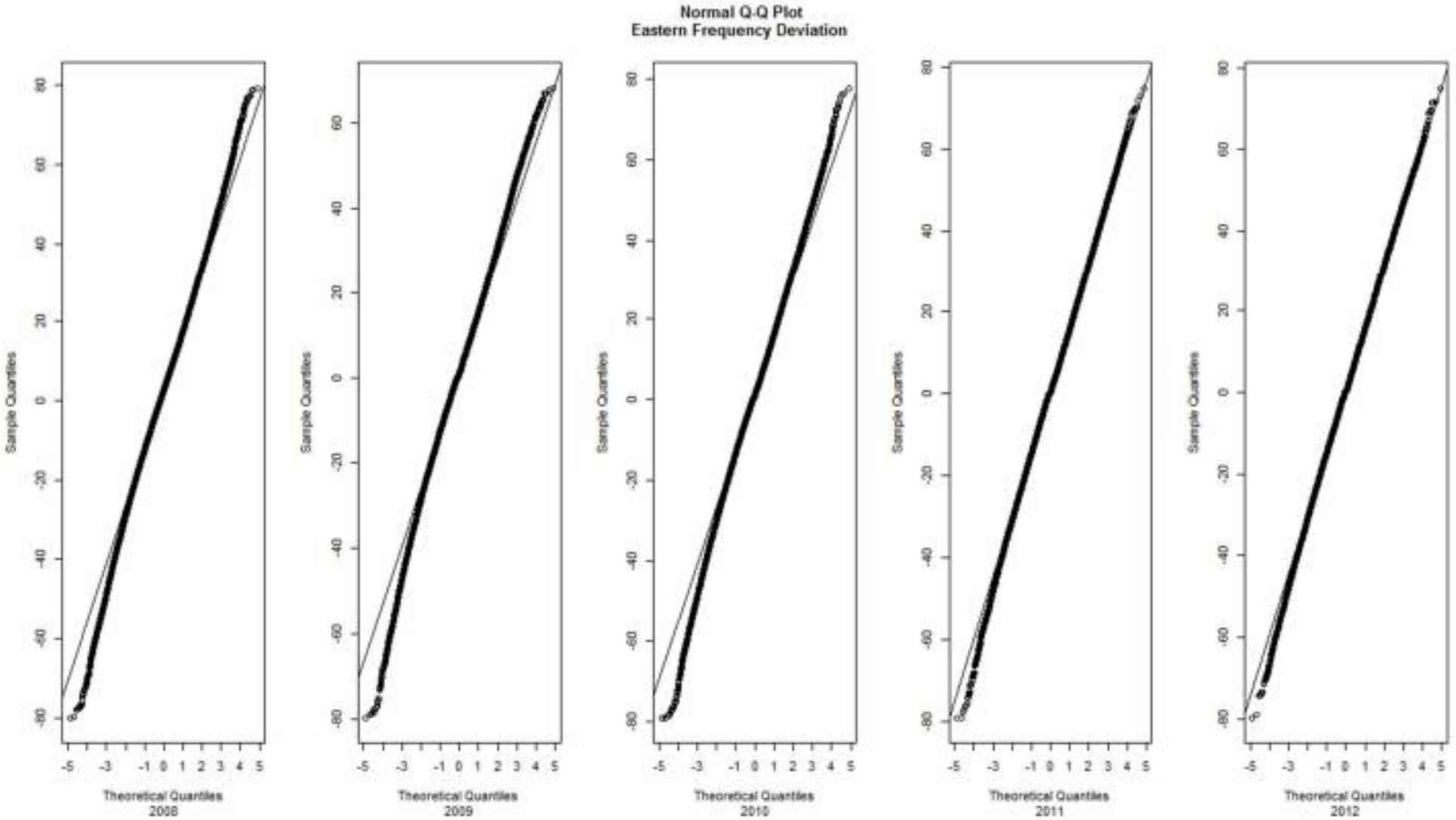
OBJECTIVE:
Identify and report on NERC Interconnections primary and secondary control performance and 5 year trends (2008 to 2012)

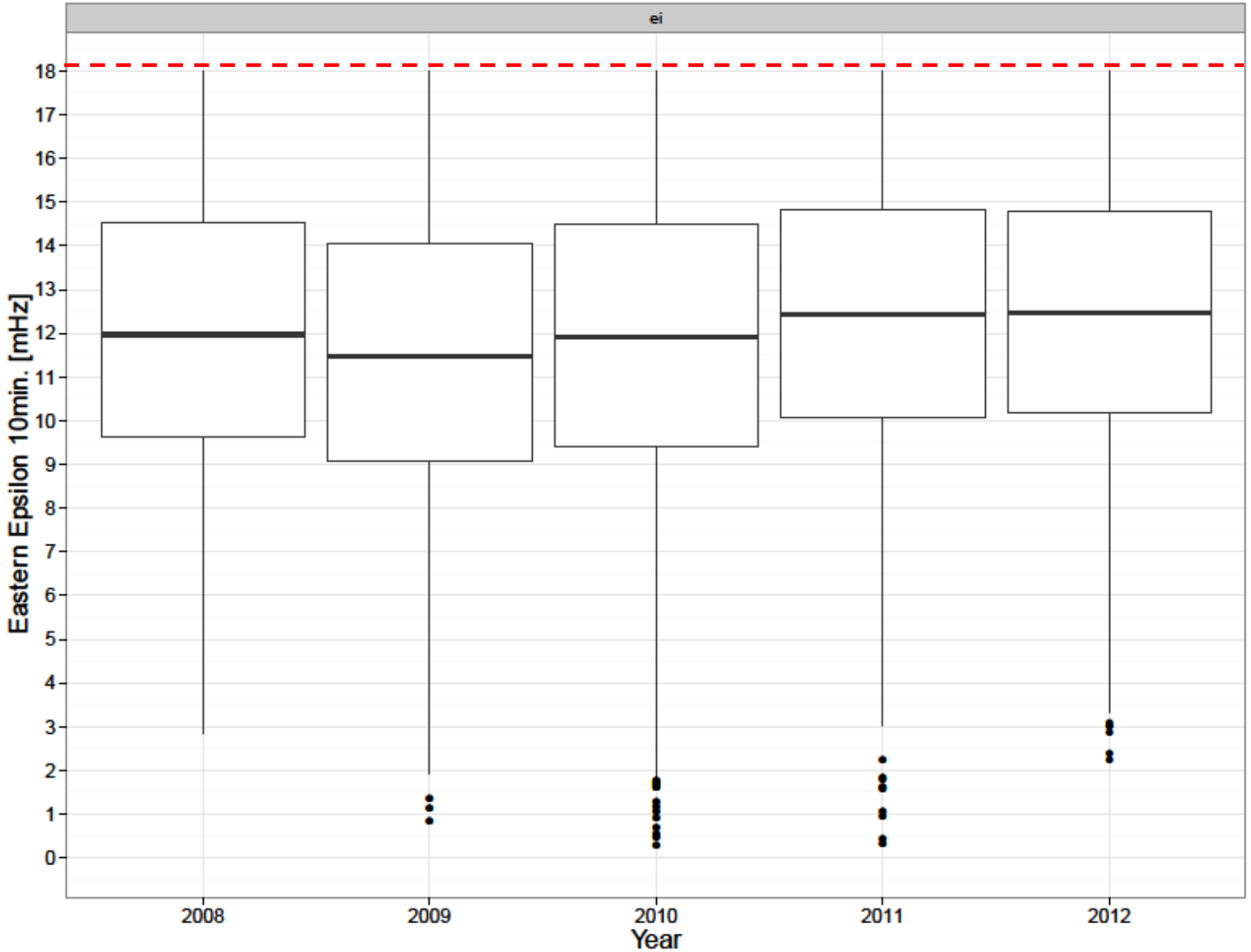
DATASETS (data quality assessment and clean-up in progress):
5-years of 1-second phasor frequency data, 5-years of 1-minute contingent-BA ACE and Interconnections NetACE data, and 5-years of frequency events (using NERC Frequency Response Standard criteria and thresholds)

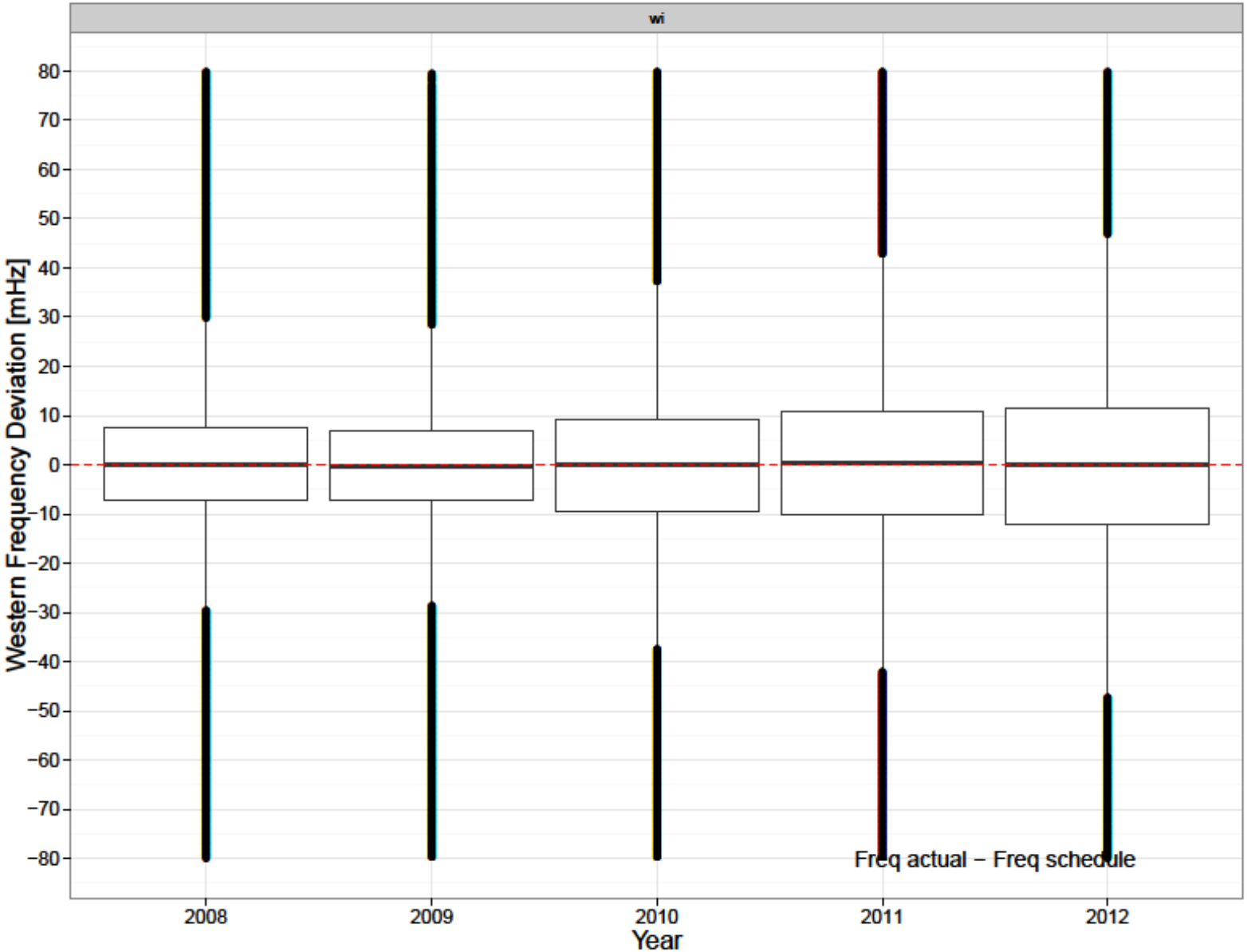
PERFORMANCE PARAMETERS (Preliminary):
Secondary Control: Frequency Deviation (include TE), and Epsilon
Primary Control: Frequency Events' Frequency-C, MW Loss, Frequency Response, A-C frequency ramps, primary withdrawn

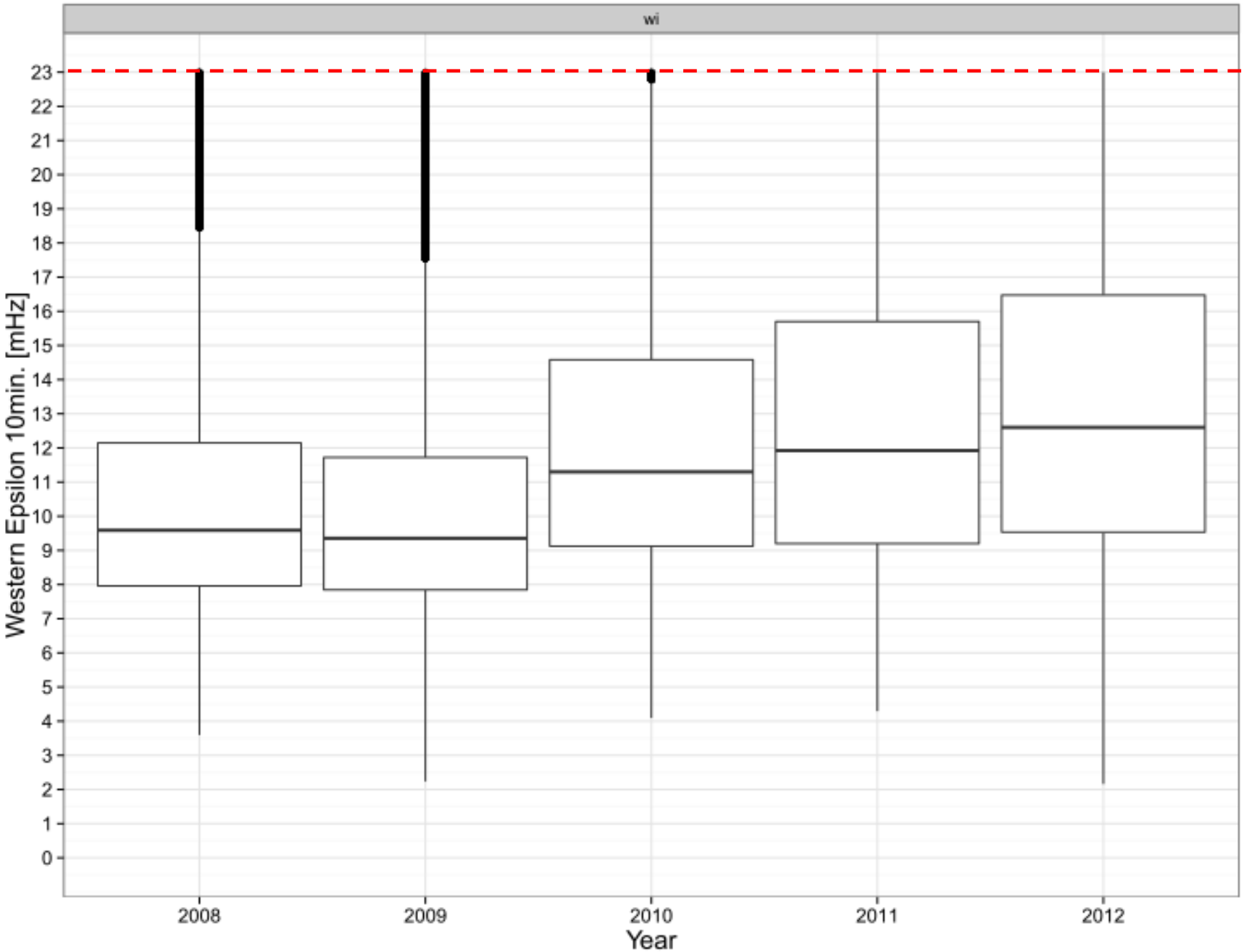
Interconnections 2012 Frequency Performance and 5-Year Trends (Preliminary Boxplots)

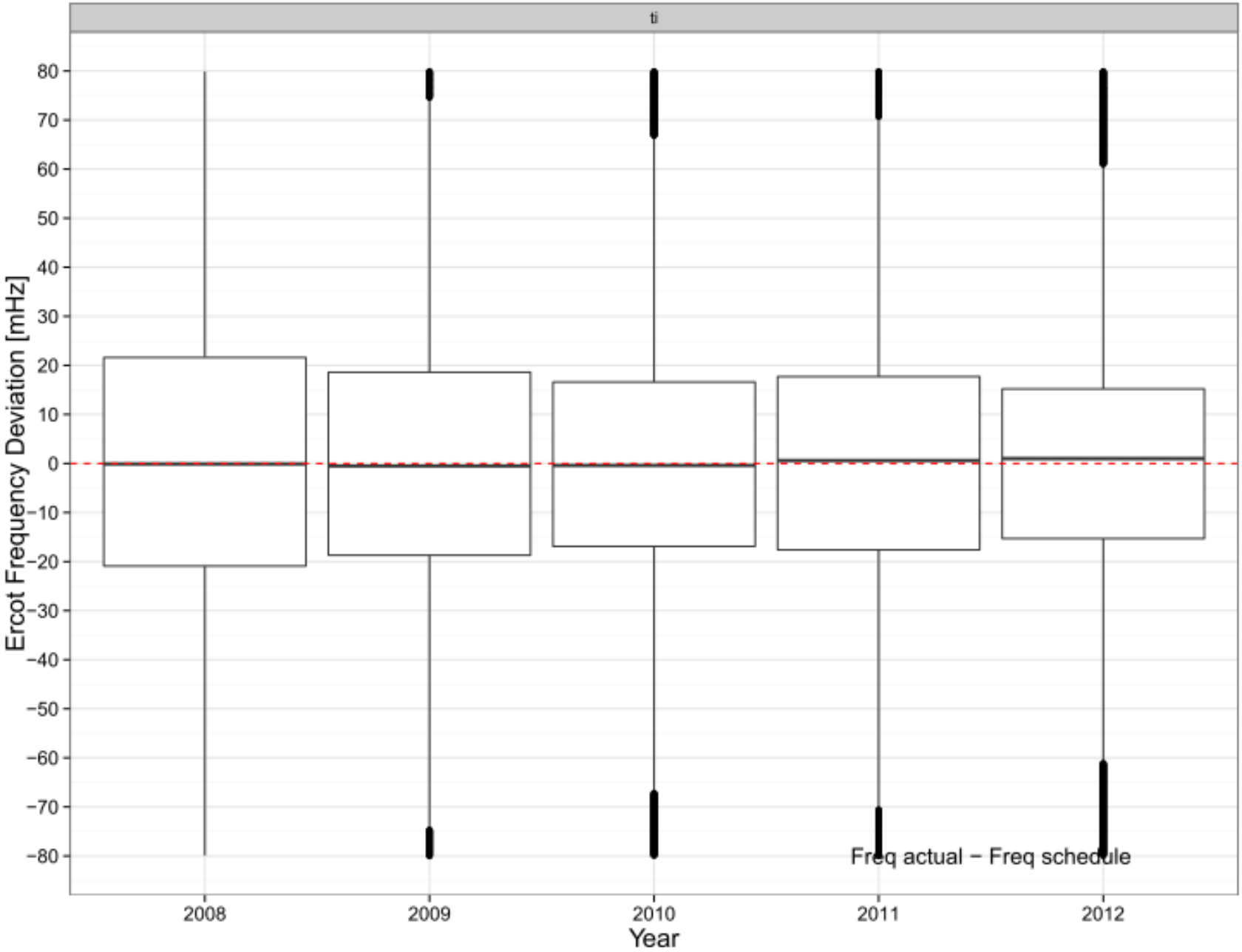

ei
Eastern Frequency Deviation [mHz]
80
70
60
50
40
30
20
10
0
−10
−20
−30
−40
−50
−60
−70
−80
Freq actual − Freq schedule
2008
2009
2010
2011
2012
Year

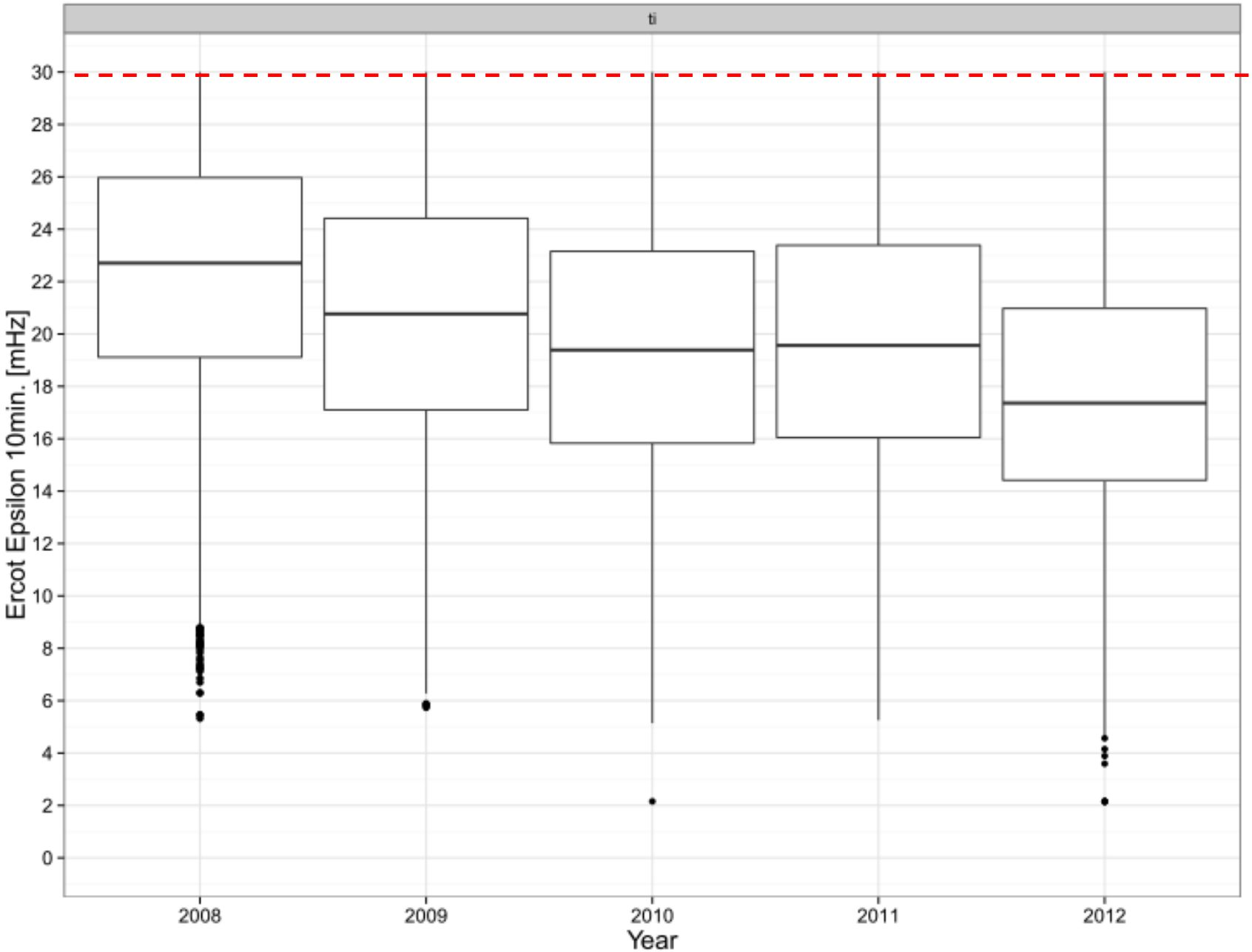

Normal Q-Q Plot
Eastern Frequency Deviation
Sample Quantiles
Theoretical Quantiles
2008
2009
2010
2011
2012


ei
Eastern Epsilon 10min. [mHz]
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
2008
2009
2010
2011
2012
Year

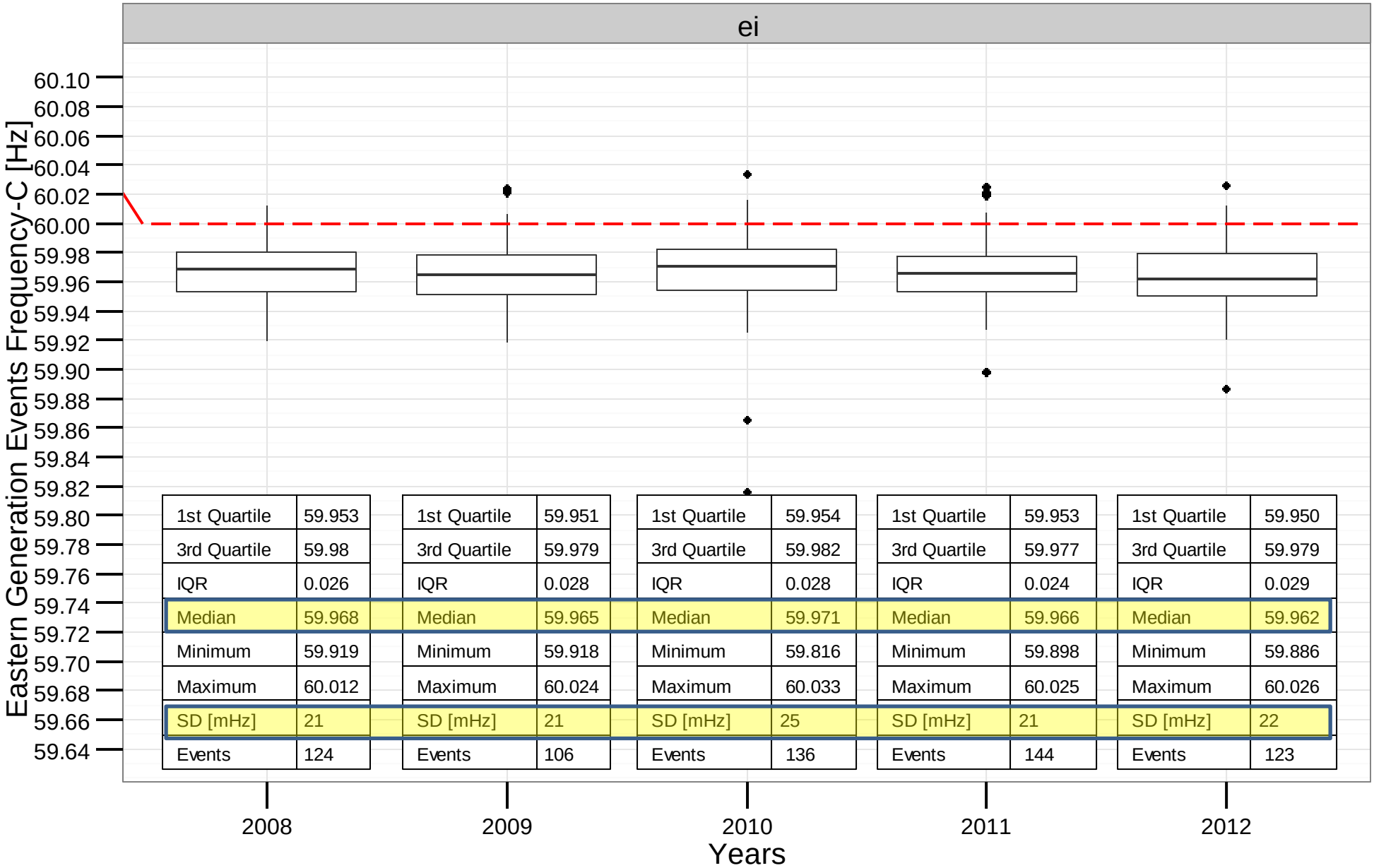

wi
Western Frequency Deviation [mHz]
80
70
60
50
40
30
20
10
0
−10
−20
−30
−40
−50
−60
−70
−80
Freq actual − Freq schedule
2008
2009
2010
2011
2012
Year


wi
Western Epsilon 10min. [mHz]
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
2008
2009
2010
2011
2012
Year

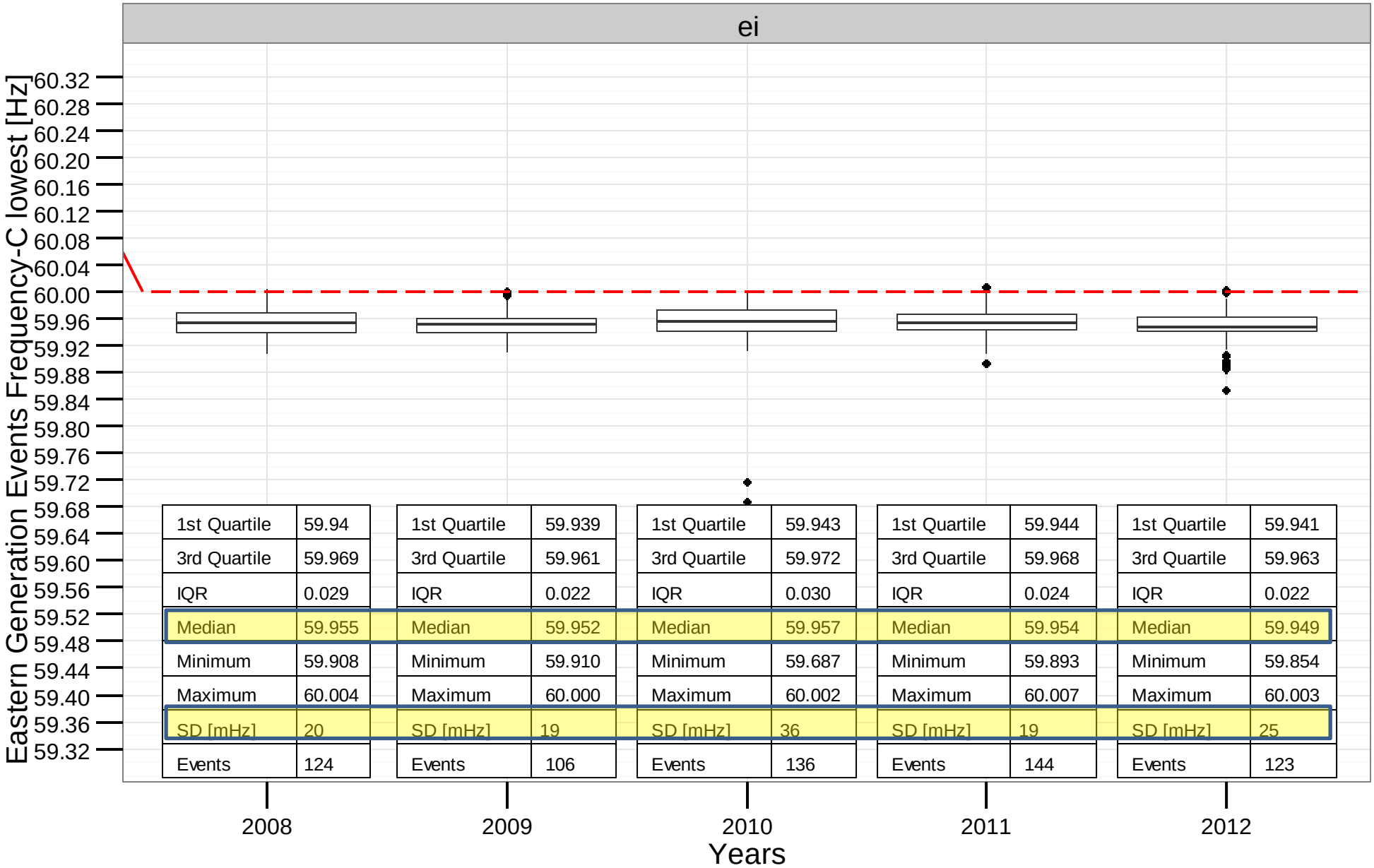

ti
Ercot Frequency Deviation [mHz]
80
70
60
50
40
30
20
10
0
−10
−20
−30
−40
−50
−60
−70
−80
Freq actual − Freq schedule
2008
2009
2010
2011
2012
Year


ti
Ercot Epsilon 10min. [mHz]
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
2008
2009
2010
2011
2012
Year

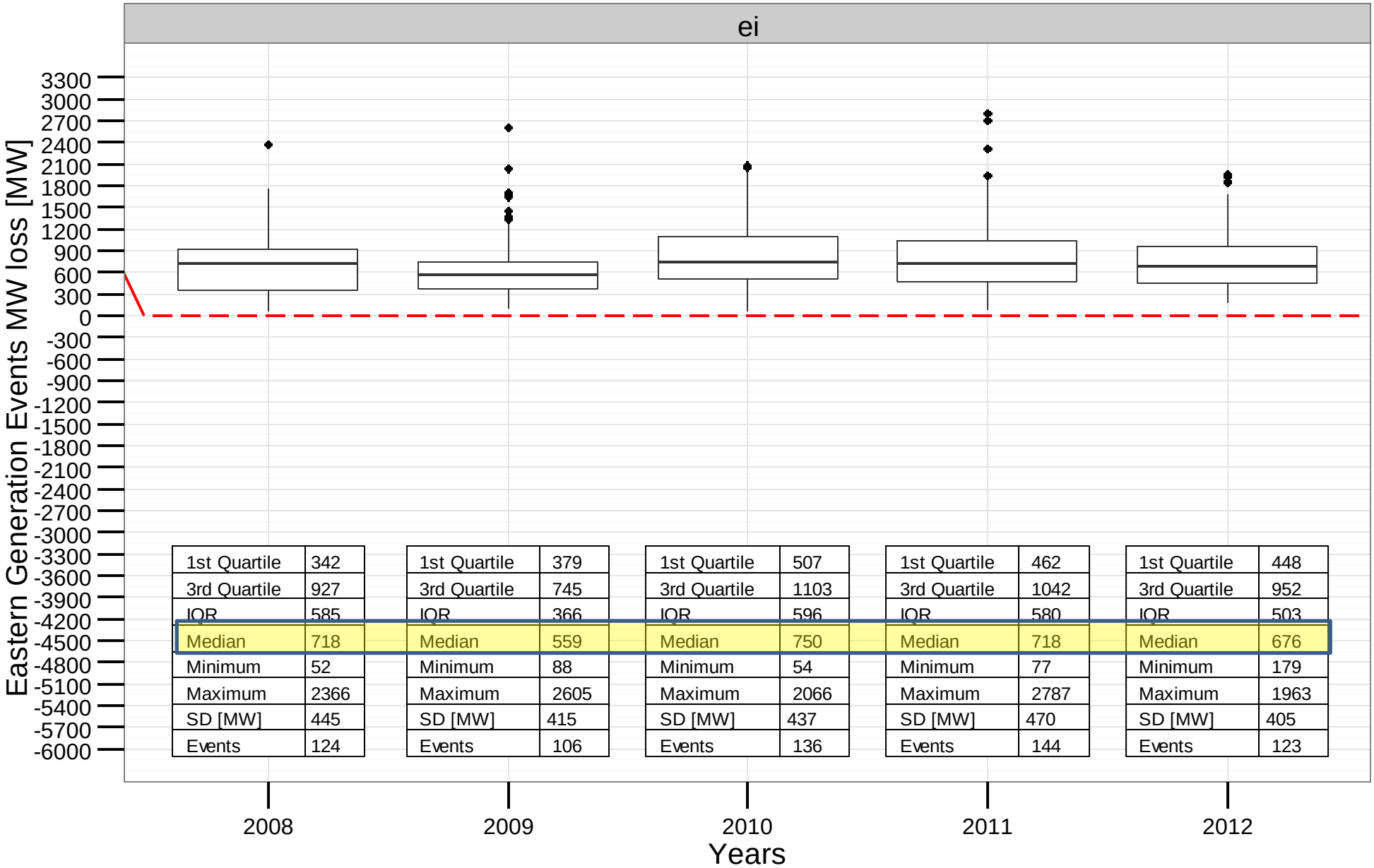
Eastern 2012 Frequency Events Characteristics and 5-Year Trends (Preliminary Boxplots)



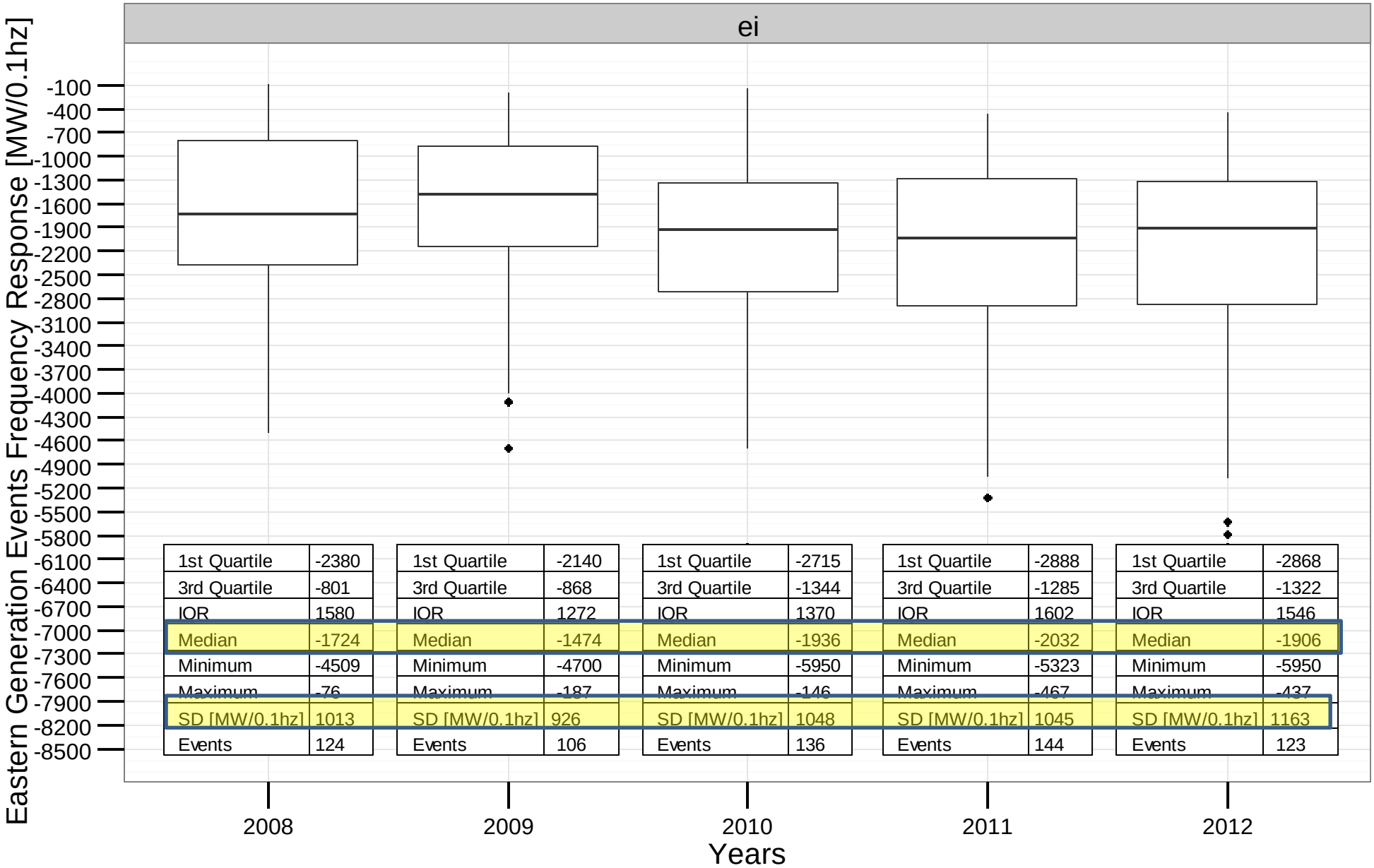
	2008	2009	2010	2011	2012
1st Quartile	59.953	59.951	59.954	59.953	59.950
3rd Quartile	59.98	59.979	59.982	59.977	59.979
IQR	0.026	0.028	0.028	0.024	0.029
Median	59.968	59.965	59.971	59.966	59.962
Minimum	59.919	59.918	59.816	59.898	59.886
Maximum	60.012	60.024	60.033	60.025	60.026
SD [mHz]	21	21	25	21	22
Events	124	106	136	144	123



	2008	2009	2010	2011	2012
1st Quartile	59.94	59.939	59.943	59.944	59.941
3rd Quartile	59.969	59.961	59.972	59.968	59.963
IQR	0.029	0.022	0.030	0.024	0.022
Median	59.955	59.952	59.957	59.954	59.949
Minimum	59.908	59.910	59.687	59.893	59.854
Maximum	60.004	60.000	60.002	60.007	60.003
SD [mHz]	20	19	36	19	25
Events	124	106	136	144	123

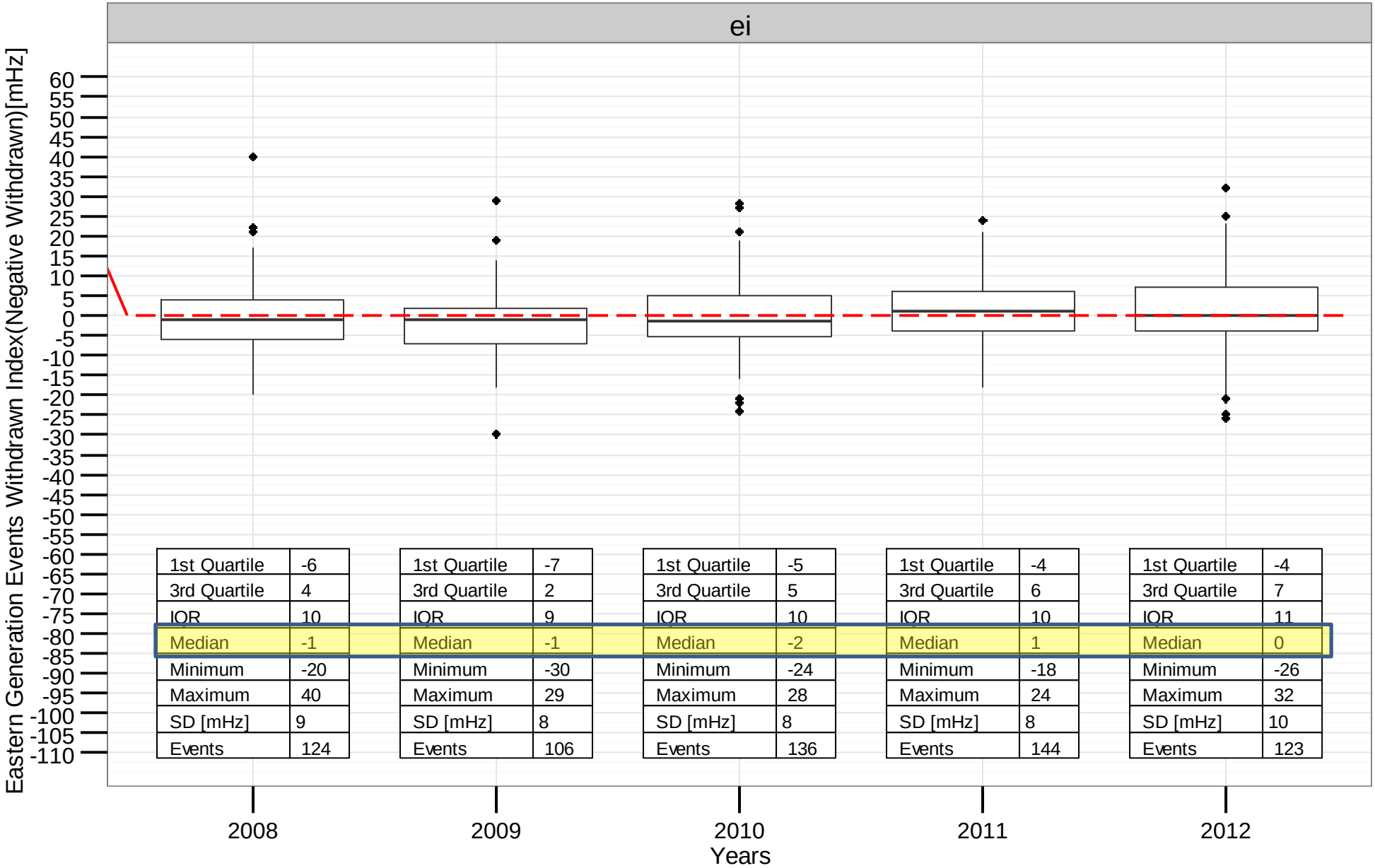


	2008	2009	2010	2011	2012
1st Quartile	342	379	507	462	448
3rd Quartile	927	745	1103	1042	952
IQR	585	366	596	580	503
Median	718	559	750	718	676
Minimum	52	88	54	77	179
Maximum	2366	2605	2066	2787	1963
SD [MW]	445	415	437	470	405
Events	124	106	136	144	123



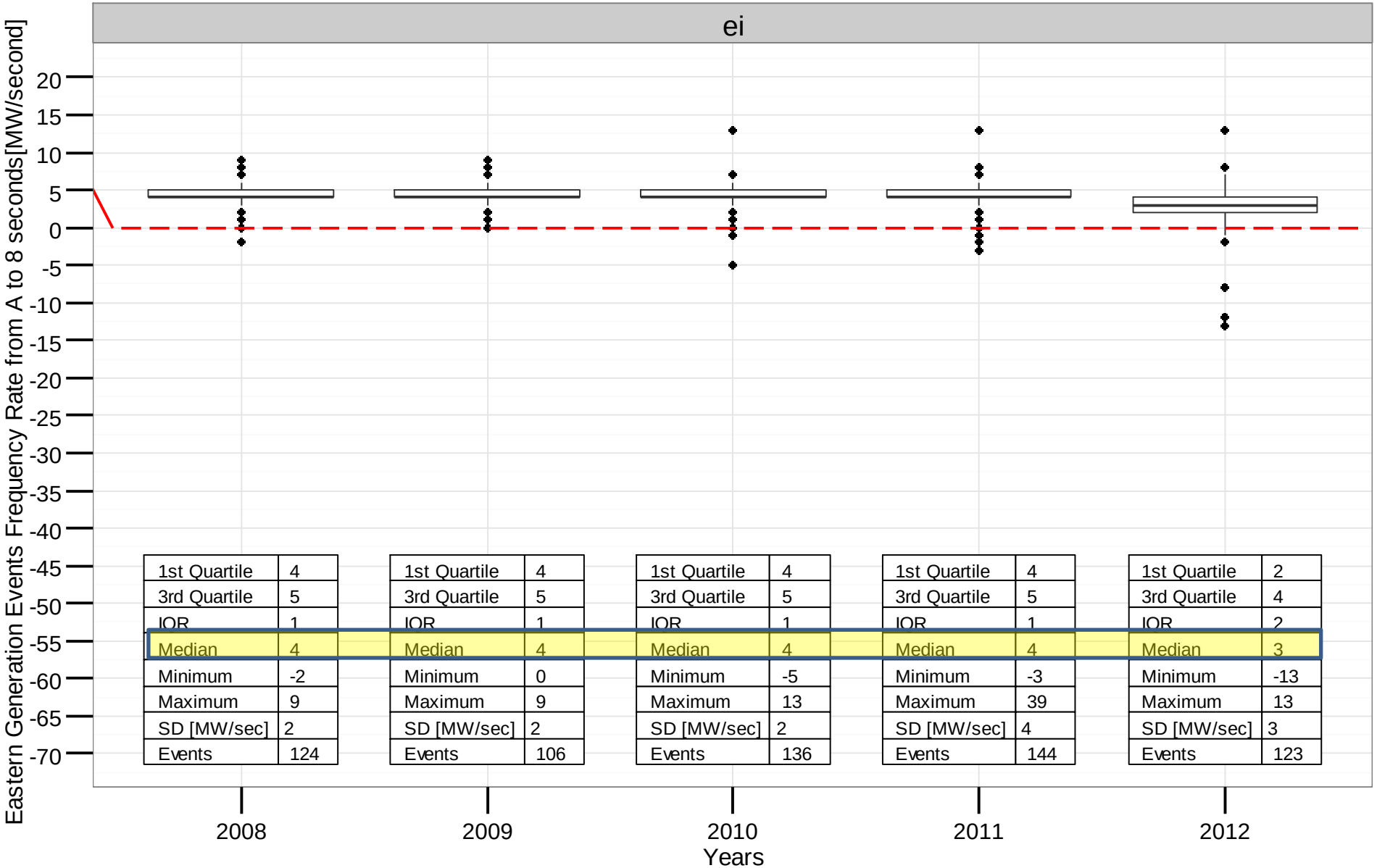
	2008	2009	2010	2011	2012
1st Quartile	-2380	-2140	-2715	-2888	-2868
3rd Quartile	-801	-868	-1344	-1285	-1322
IQR	1580	1272	1370	1602	1546
Median	-1724	-1474	-1936	-2032	-1906
Minimum	-4509	-4700	-5950	-5323	-5950
Maximum	-76	-187	-146	-467	-437
SD [MW/0.1hz]	1013	926	1048	1045	1163
Events	124	106	136	144	123

Sustainability Index – Index Calculated as the average frequency from T_{zero} plus 62 seconds to T_{zero} plus 80 seconds minus the Value(B) (negative indicates primary)



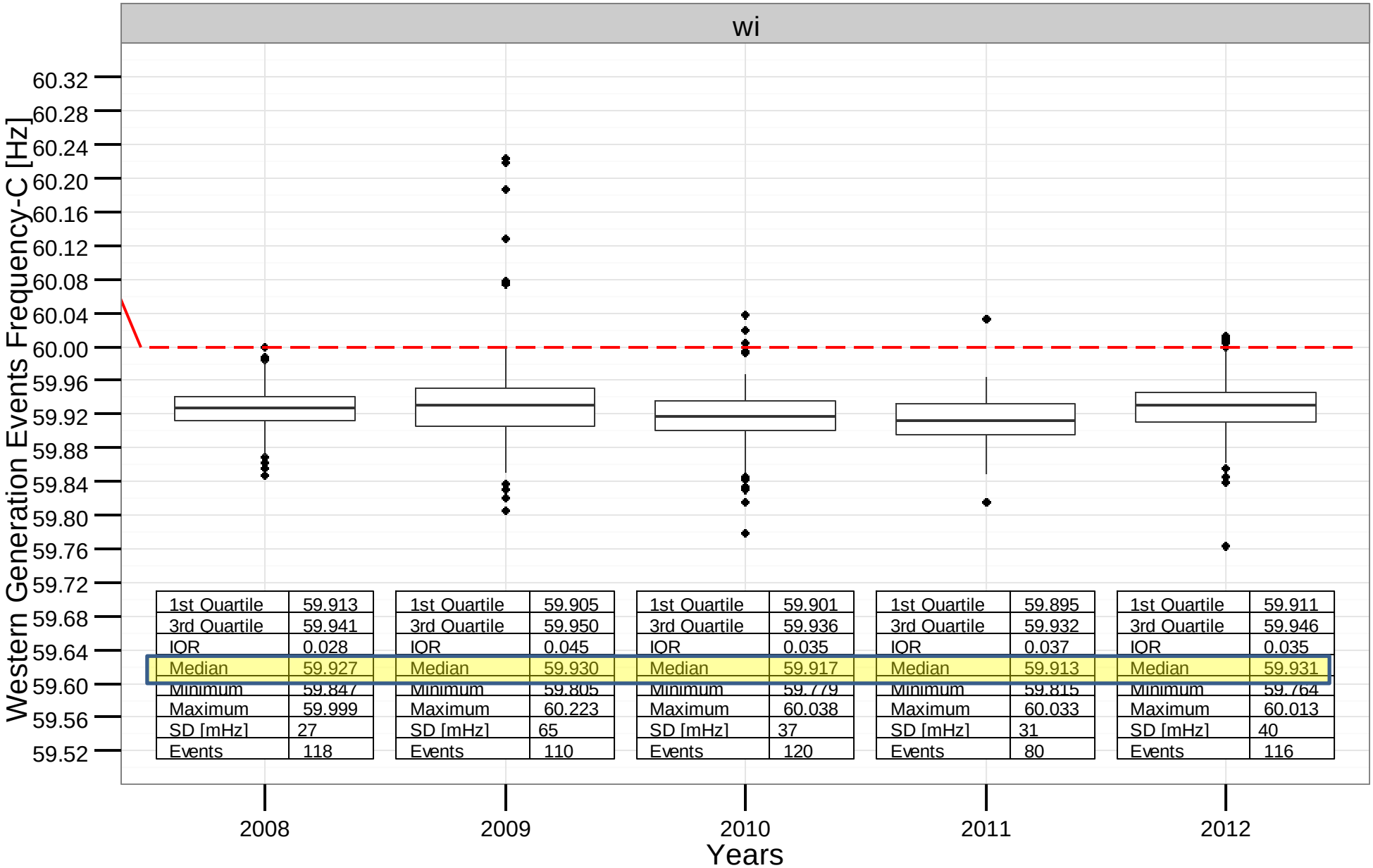
	2008	2009	2010	2011	2012
1st Quartile	-6	-7	-5	-4	-4
3rd Quartile	4	2	5	6	7
IQR	10	9	10	10	11
Median	-1	-1	-2	1	0
Minimum	-20	-30	-24	-18	-26
Maximum	40	29	28	24	32
SD [mHz]	9	8	8	8	10
Events	124	106	136	144	123

FreqRate_A_T8 =1000*[Value(A) – Freq(T8)]/8 mHz/second

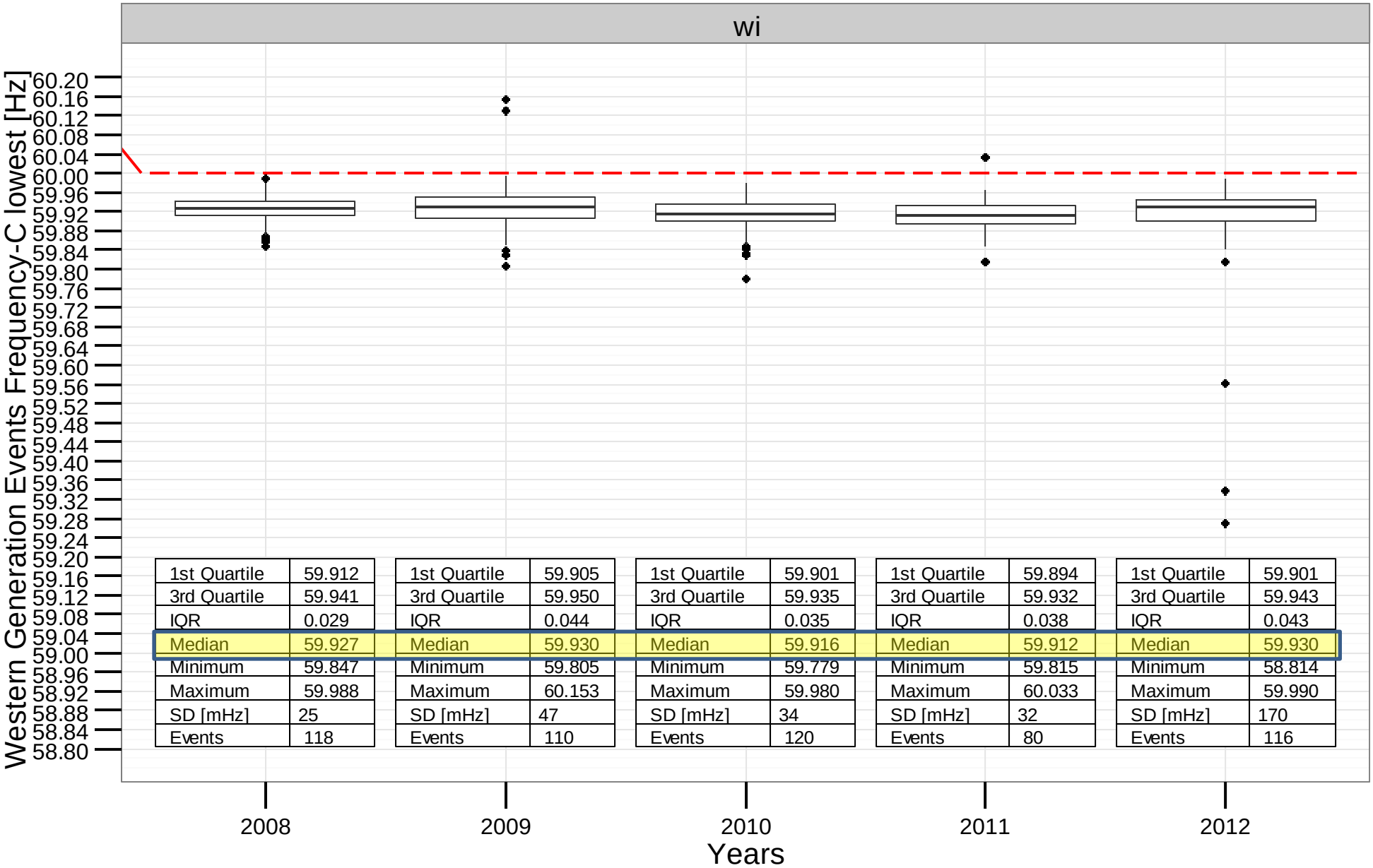


	2008	2009	2010	2011	2012
1st Quartile	4	4	4	4	2
3rd Quartile	5	5	5	5	4
IQR	1	1	1	1	2
Median	4	4	4	4	3
Minimum	-2	0	-5	-3	-13
Maximum	9	9	13	39	13
SD [MW/sec]	2	2	2	4	3
Events	124	106	136	144	123

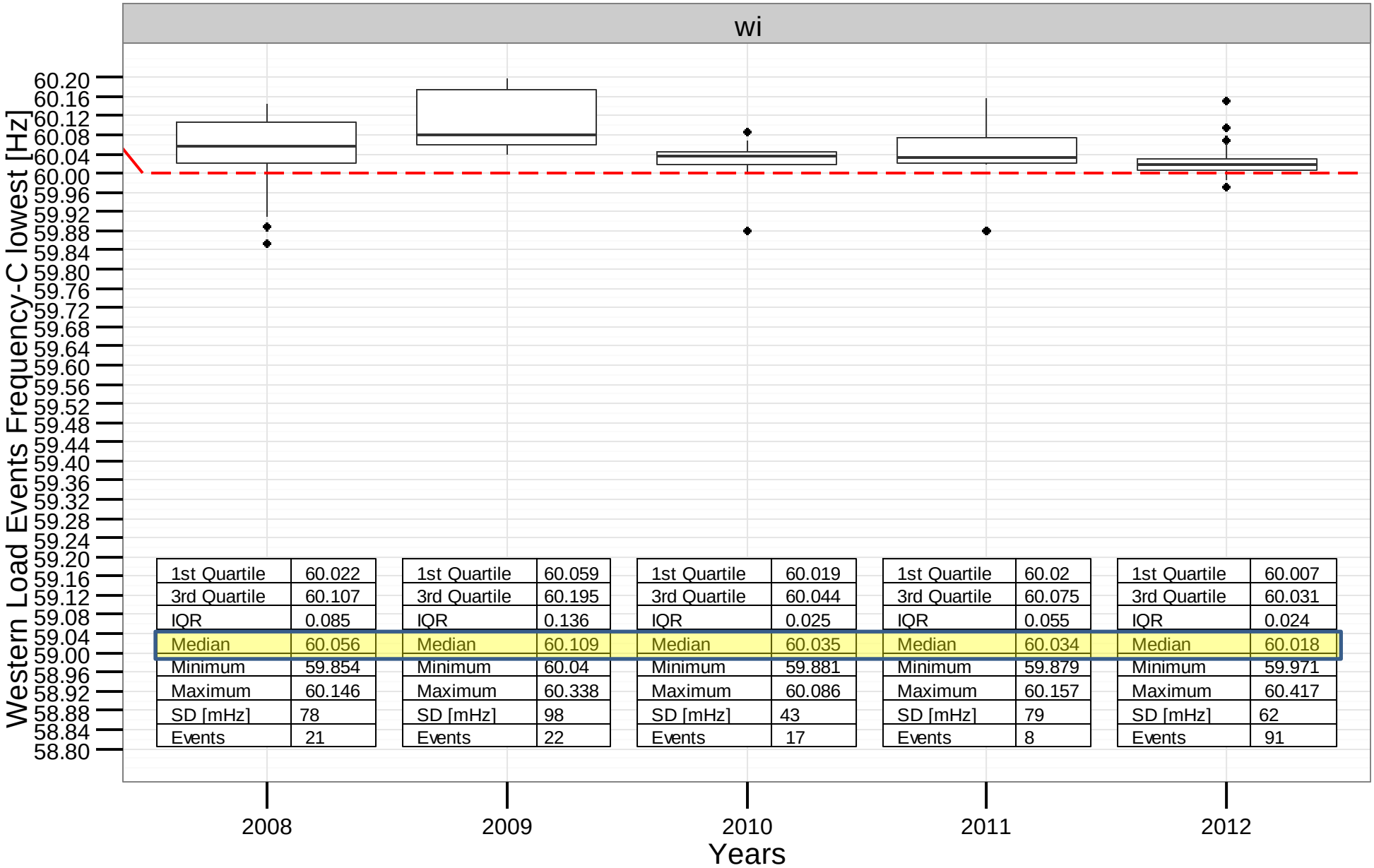
Western 2012 Frequency Events Characteristics and 5-Year Trends (Preliminary Boxplots)



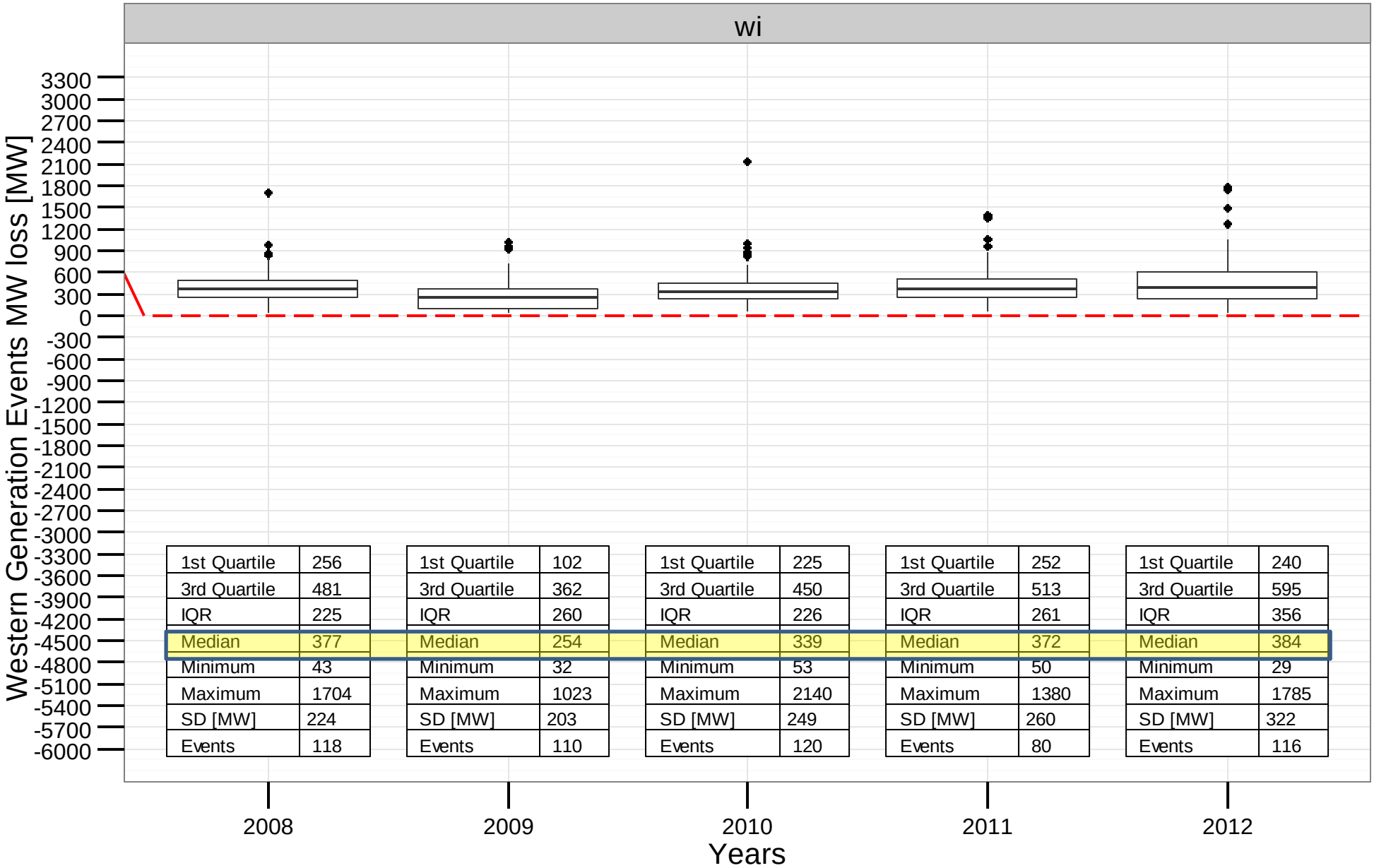
	2008	2009	2010	2011	2012
1st Quartile	59.913	59.905	59.901	59.895	59.911
3rd Quartile	59.941	59.950	59.936	59.932	59.946
IQR	0.028	0.045	0.035	0.037	0.035
Median	59.927	59.930	59.917	59.913	59.931
Minimum	59.847	59.805	59.779	59.815	59.764
Maximum	59.999	60.223	60.038	60.033	60.013
SD [mHz]	27	65	37	31	40
Events	118	110	120	80	116



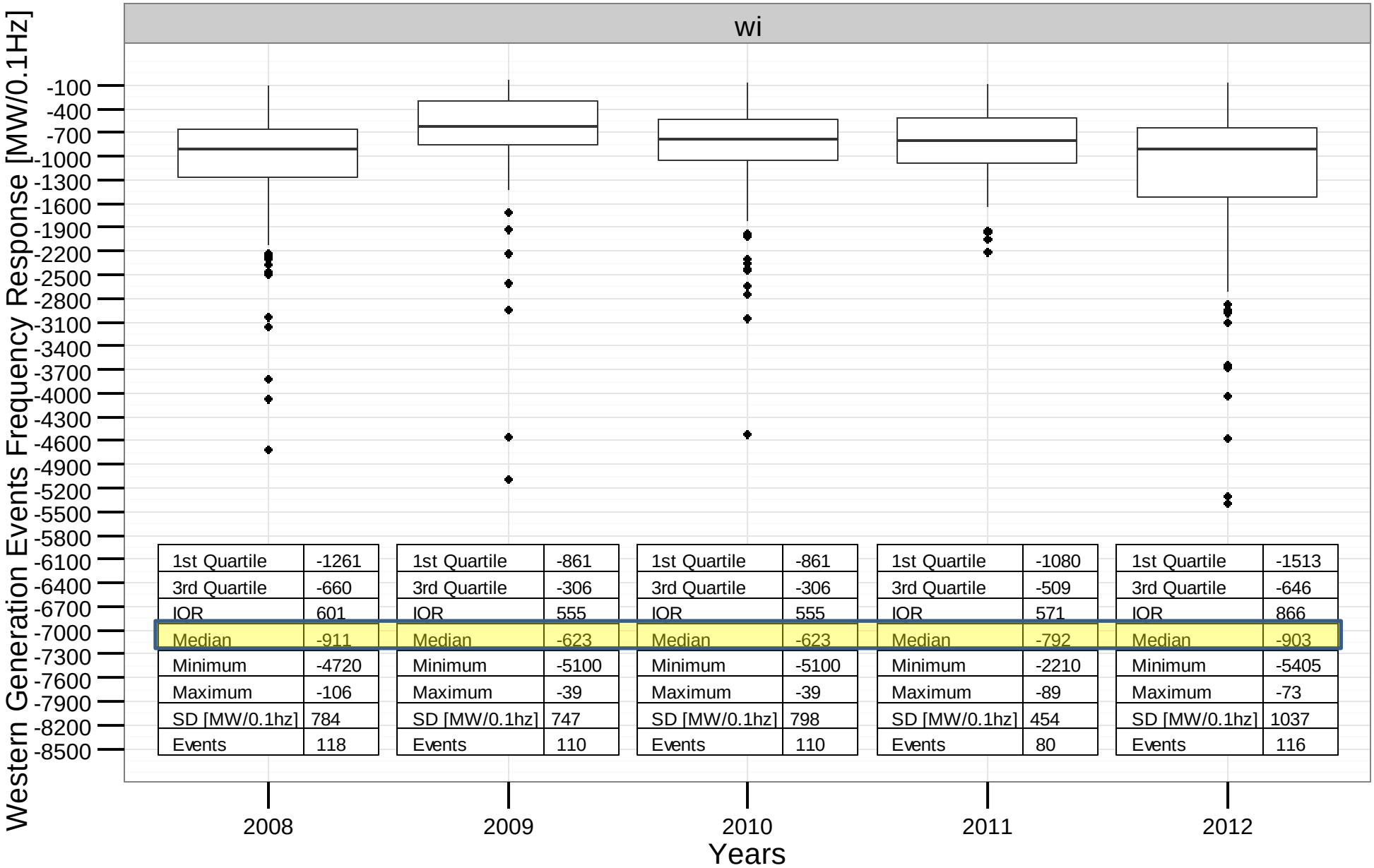
	2008	2009	2010	2011	2012
1st Quartile	59.912	59.905	59.901	59.894	59.901
3rd Quartile	59.941	59.950	59.935	59.932	59.943
IQR	0.029	0.044	0.035	0.038	0.043
Median	59.927	59.930	59.916	59.912	59.930
Minimum	59.847	59.805	59.779	59.815	58.814
Maximum	59.988	60.153	59.980	60.033	59.990
SD [mHz]	25	47	34	32	170
Events	118	110	120	80	116



	2008	2009	2010	2011	2012
1st Quartile	60.022	60.059	60.019	60.02	60.007
3rd Quartile	60.107	60.195	60.044	60.075	60.031
IQR	0.085	0.136	0.025	0.055	0.024
Median	60.056	60.109	60.035	60.034	60.018
Minimum	59.854	60.04	59.881	59.879	59.971
Maximum	60.146	60.338	60.086	60.157	60.417
SD [mHz]	78	98	43	79	62
Events	21	22	17	8	91

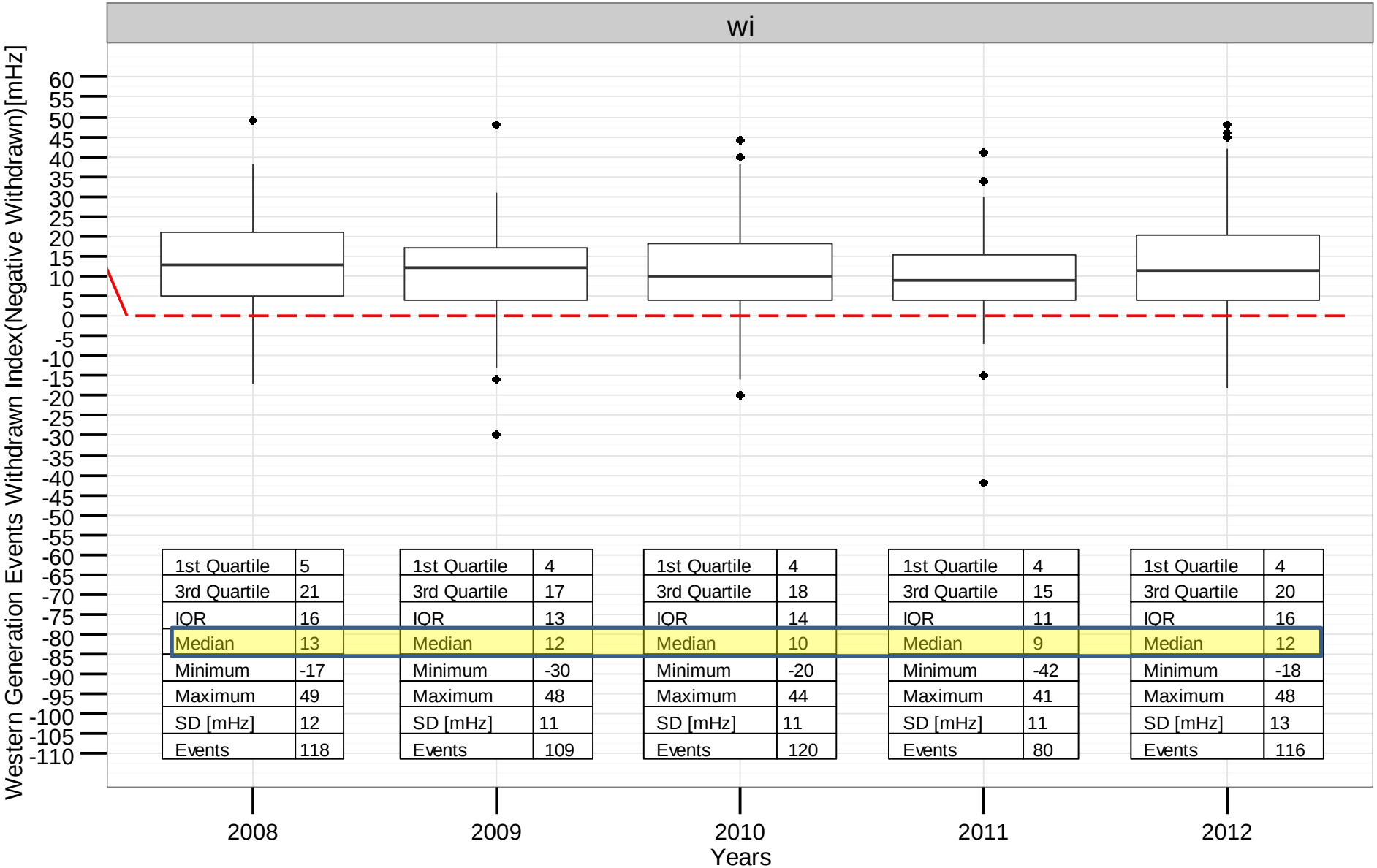


	2008	2009	2010	2011	2012
1st Quartile	256	102	225	252	240
3rd Quartile	481	362	450	513	595
IQR	225	260	226	261	356
Median	377	254	339	372	384
Minimum	43	32	53	50	29
Maximum	1704	1023	2140	1380	1785
SD [MW]	224	203	249	260	322
Events	118	110	120	80	116



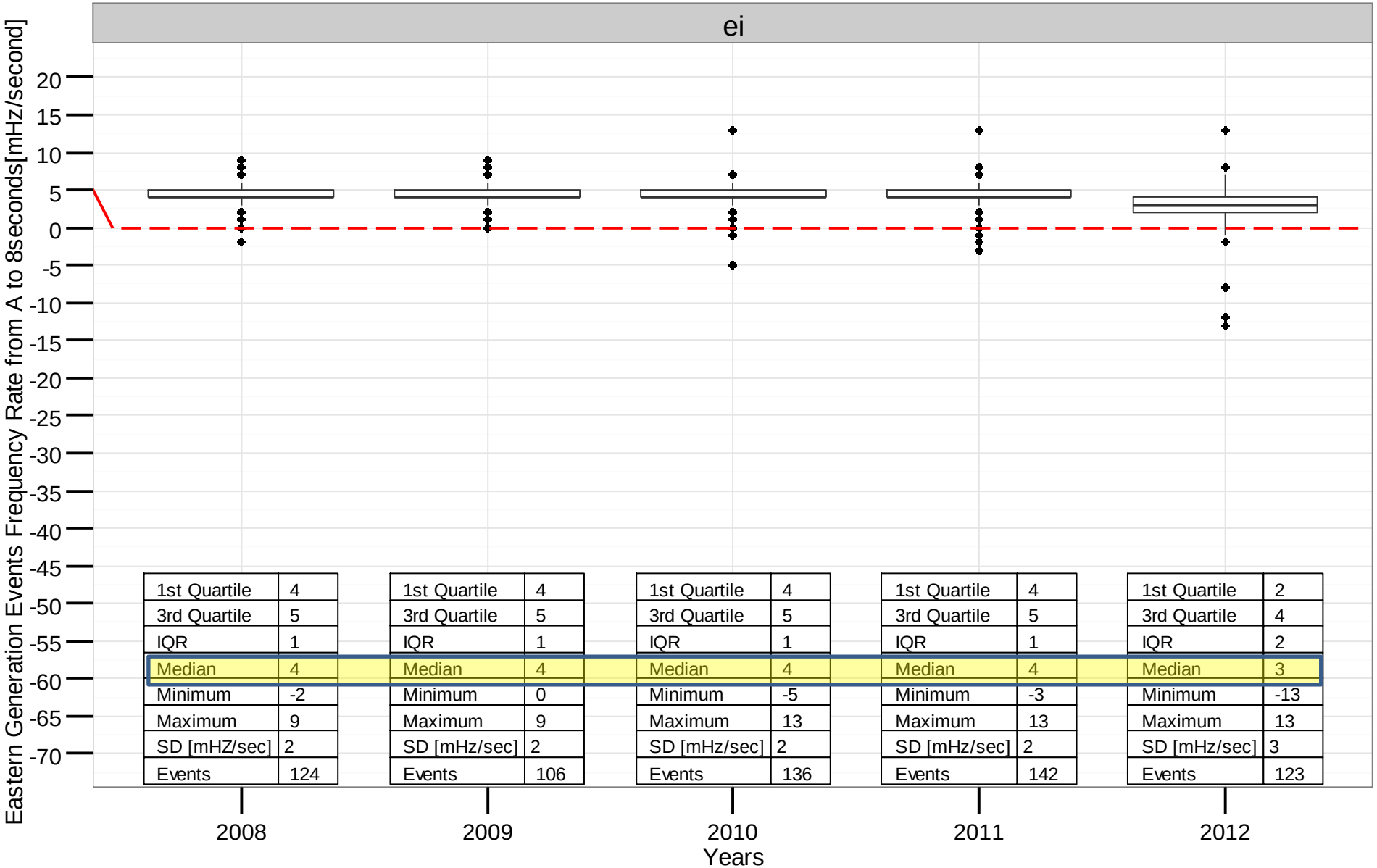
	2008	2009	2010	2011	2012
1st Quartile	-1261	-861	-861	-1080	-1513
3rd Quartile	-660	-306	-306	-509	-646
IQR	601	555	555	571	866
Median	-911	-623	-623	-792	-903
Minimum	-4720	-5100	-5100	-2210	-5405
Maximum	-106	-39	-39	-89	-73
SD [MW/0.1hz]	784	747	798	454	1037
Events	118	110	110	80	116

Sustainability Index – Index Calculated as the average frequency from T_{zero} plus 62 seconds to T_{zero} plus 80 seconds minus the Value(B) (negative indicates)



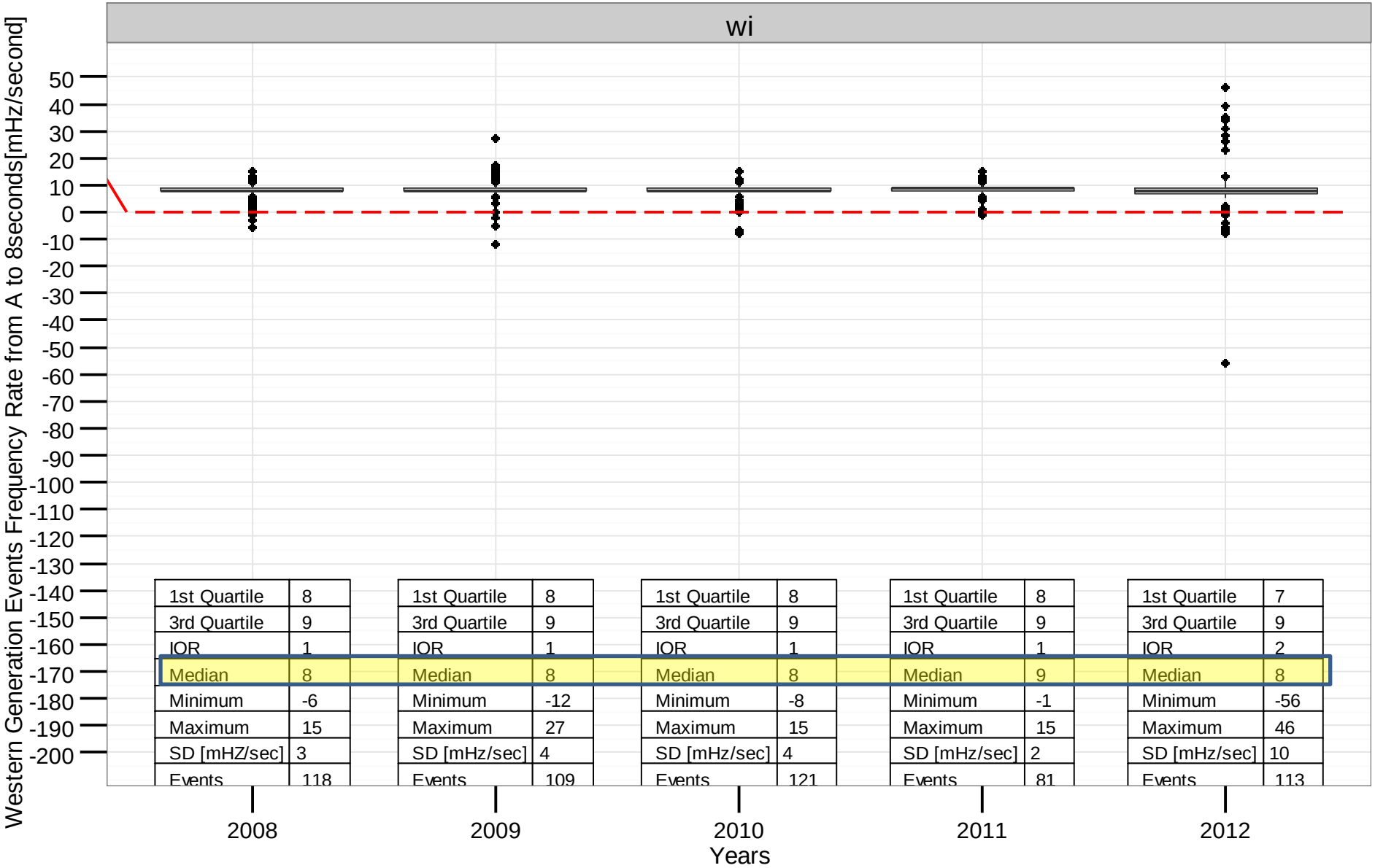
	2008	2009	2010	2011	2012
1st Quartile	5	4	4	4	4
3rd Quartile	21	17	18	15	20
IQR	16	13	14	11	16
Median	13	12	10	9	12
Minimum	-17	-30	-20	-42	-18
Maximum	49	48	44	41	48
SD [mHz]	12	11	11	11	13
Events	118	109	120	80	116

FreqRate_A_T8 =1000*[Value(A) – Freq(T8)]/8 mHz/second



	2008	2009	2010	2011	2012
1st Quartile	4	4	4	4	2
3rd Quartile	5	5	5	5	4
IQR	1	1	1	1	2
Median	4	4	4	4	3
Minimum	-2	0	-5	-3	-13
Maximum	9	9	13	13	13
SD [mHZ/sec]	2	2	2	2	3
Events	124	106	136	142	123

FreqRate_A_T8 =1000*[Value(A) – Freq(T8)]/8 mHz/second



	2008	2009	2010	2011	2012
1st Quartile	8	8	8	8	7
3rd Quartile	9	9	9	9	9
IQR	1	1	1	1	2
Median	8	8	8	9	8
Minimum	-6	-12	-8	-1	-56
Maximum	15	27	15	15	46
SD [mHZ/sec]	3	SD [mHz/sec] 4	SD [mHz/sec] 4	SD [mHz/sec] 2	SD [mHz/sec] 10
Events	118	109	121	81	113