

**BMW
GROUP**



EEC TEAM DATA ANALYSIS

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PMP TF3

EEC FILES: INTRODUCTION

17

Labs announced participation

16

Labs delivered data

1

Lab (Lab B) has withdrawn its data from emission evaluation

75

EEC Files delivered

160

MByte of Data

203000

Data lines analysed

- EEC Files: brake Event-based files
 - are derived from time-based EED files
 - Contain data from bedding and emission cycles
 - Should contain 303 data lines per cycle
 - 1 data line = data for one of the 303 brake events

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD		
	Sect #	Stop #	brake_data_begin Stop	Stop Time sec	Time of stop	Date of stop	Brk Spd kph	Brk Spd kph	Rel Spd Setpoint kph	Rel Spd kph	Rot Spd avg - time rpm	Decel avg - time m/s²	Decel avg - dist m/s²	Torque avg - time N.m	Torque avg - dist N.m	pressure avg - dist bar	mu avg - dist	Embed Initial Rotator °C	Embed Final Rotator °C	Embed Max Rotator °C	Initial In pad °C	Final In pad °C	Max In pad °C	Initial Out pad °C	Final Out pad °C	Max Out pad °C	CSpdA kph	Air Temp °C	Humidity %	Friction Work J/kg		
6	1301	1	2174	5,8	10:36:58	03.12.2021	20,80	0,50	0,00	86,13	0,968	140,5	141,1	3,0	0,088	22,5	24,5	24,7	21,5	22,5	22,6										Sum 11875,6	
7	1301	2	2175	6,9	10:37:38	03.12.2021	23,30	0,60	5,40	116,12	0,862	123,3	104,9	2,0	0,076	24,4	24,5	25,7	22,4	23,4	24,5											
8	1301	3	2176	4,1	10:38:05	03.12.2021	15,40	4,40	4,38	79,25	0,768	100,5	99,5	1,8	0,076	24,5	24,8	25,6	23,5	23,9	23,6											
9	1301	4	2177	6,0	10:38:23	03.12.2021	26,00	7,20	7,12	135,38	0,873	113,2	112,7	2,2	0,140	25,5	25,4	26,6	23,3	23,4	24,6											
10	1301	5	2178	3,1	10:38:49	03.12.2021	25,00	16,70	16,90	170,08	0,757	96,5	96,4	1,6	0,059	25,5	25,5	26,5	23,6	24,4	24,8											
11	1301	6	2179	8,6	10:39:00	03.12.2021	19,70	0,50	0,23	78,62	0,472	191,0	140,6	4,8	0,012	26,0	28,3	31,3	24,5	25,5	26,5											
12	1301	7	2180	5,8	10:39:37	03.12.2021	32,60	0,50	0,06	133,89	1,528	220,3	218,9	5,5	0,112	27,3	30,3	30,4	25,4	26,4	26,6											
13	1301	8	2181	5,1	10:41:38	03.12.2021	27,80	11,80	11,89	160,20	0,892	115,3	114,6	2,2	0,136	28,3	29,3	29,5	26,3	26,4	26,9											
14	1301	9	2182	6,0	10:41:54	03.12.2021	29,50	9,70	9,57	181,21	0,920	121,7	121,2	2,4	0,141	29,4	30,3	31,3	26,4	26,5	27,4											
15	1301	10	2183	5,9	10:42:21	03.12.2021	32,10	9,50	9,38	170,04	1,054	142,6	141,6	3,0	0,104	30,3	32,2	32,4	27,3	27,4	28,4											
16	1301	11	2184	4,8	10:42:41	03.12.2021	14,70	0,50	0,14	61,46	0,829	110,6	109,1	2,0	0,121	31,2	31,3	31,4	28,3	28,4	28,6											
17	1301	12	2185	3,9	10:43:04	03.12.2021	59,40	47,60	47,44	440,32	0,846	98,9	98,8	1,6	0,053	31,2	33,2	33,3	28,4	28,4	28,6											
18	1301	13	2186	4,0	10:43:22	03.12.2021	47,50	36,20	36,11	345,07	0,801	97,0	97,0	1,6	0,041	32,2	34,2	34,2	29,5	29,3	29,6											
19	1301	14	2187	4,0	10:44:46	03.12.2021	36,10	25,50	25,36	261,63	0,895	116,2	116,1	2,1	0,141	32,2	34,2	34,4	29,4	29,2	29,5											
20	1301	15	2188	3,0	10:44:54	03.12.2021	25,40	16,40	16,37	178,91	0,652	76,0	76,3	0,8	0,132	33,2	33,2	33,4	29,3	29,3	30,4											
21	1301	16	2189	5,5	10:45:00	03.12.2021	17,80	0,50	0,10	73,83	0,881	116,2	114,4	2,1	0,139	33,2	34,2	34,3	29,3	30,2	30,5											
22	1301	17	2190	8,7	10:45:43	03.12.2021	42,00	0,50	0,03	173,06	1,327	187,9	184,7	4,0	0,134	33,2	37,0	38,1	30,4	32,3	32,4											
23	1301	18	2191	9,7	10:46:06	03.12.2021	41,90	0,50	0,03	172,64	1,189	159,7	159,9	3,1	0,145	36,0	41,0	41,2	32,2	34,2	34,4											
24	1301	19	2192	3,0	10:46:32	03.12.2021	30,70	12,50	12,33	174,94	1,755	255,8	255,0	5,7	0,106	39,0	42,4	42,5	34,1	35,2	35,3											
25	1301	20	2193	4,7	10:46:40	03.12.2021	12,40	0,50	0,28	51,89	0,712	82,9	85,0	0,9	0,140	41,0	41,0	41,3	35,1	35,0	35,2											
26	1301	21	2194	9,8	10:47:27	03.12.2021	45,70	0,50	0,12	186,01	1,276	178,4	175,3	3,5	0,144	38,9	45,4	45,5	35,0	37,0	38,1											
27	1301	22	2195	6,2	10:48:53	03.12.2021	45,70	0,60	0,00	186,46	1,794	177,7	173,4	3,3	0,148	43,3	46,3	46,3	37,0	40,3	40,3											

- Software Tools used
 - R: for data agglomeration and analysis
 - Tableau: for visualization

EEC TEAM: FIRST STEPS & FINDINGS

First EEC-Files with Version 0

■ Main Issues:

- Header lines different to example file
- Header sections missing
- Leading blank lines deleted / structure changed
- Naming of Excel tabs no unique
"Bedd. 1" vs. "Bed.1" etc
- Data strategy for missing data or not connected sensors different for different labs
=> Air temp or air speed = -40 °C
- Big variance in data strategy for Columns A...C
"Sect #", "Stop #", "brake_data_begin Stop"
- Missing bedding or emissions measurements

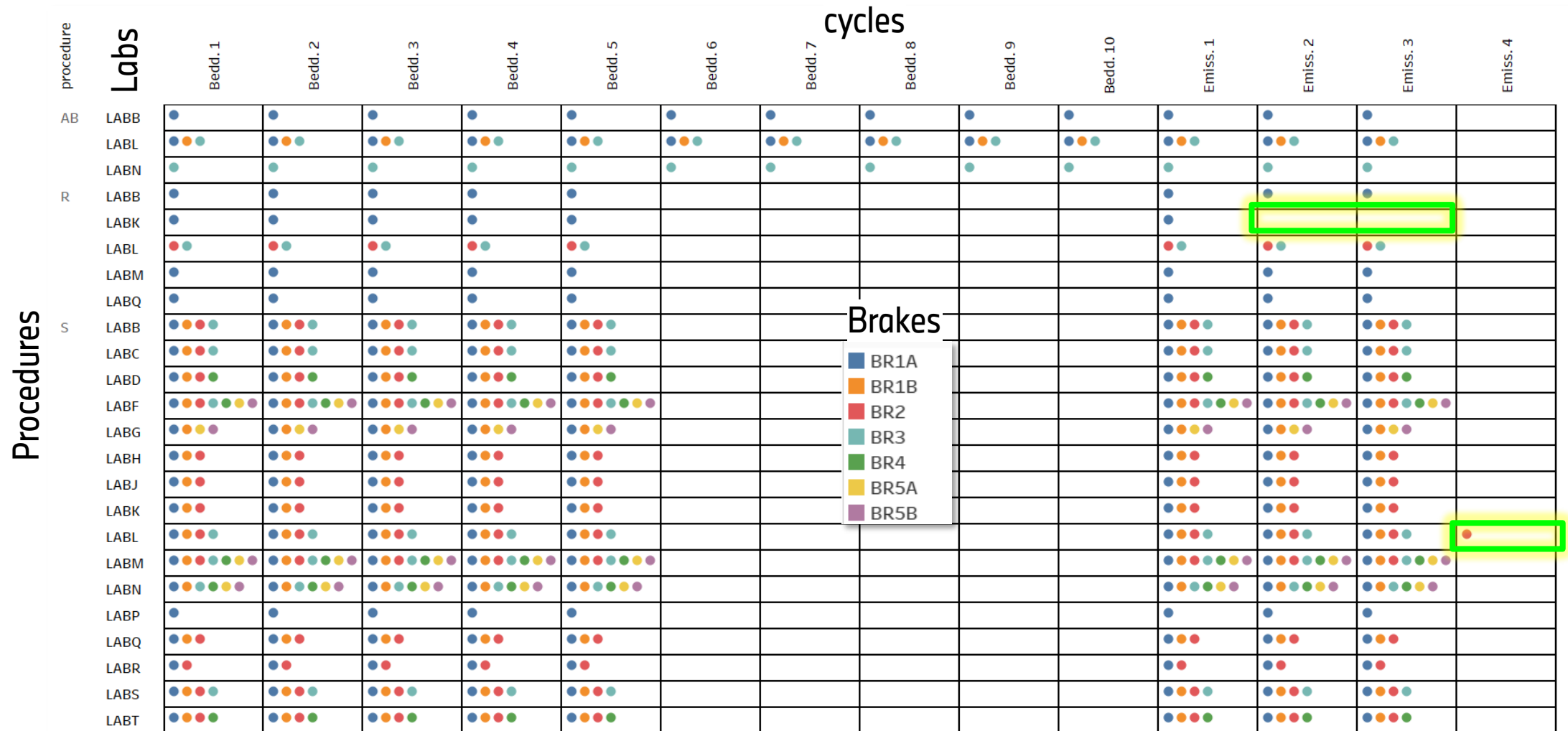
	A	B	C	D	E	F	
1			brake_data_begin				
2	Sect	Stop	Stop	Stop	Time	Date	Brk
3	#	#	Stop	Time	of stop	of stop	Set
4				sec			k
5							
6	101	1					
7	101	2					

	A	B	C	D	E	F	G	H	I
1									
2			brake_data_begin						
3	Sect	Stop	Stop	Stop	Time	Date	Brk Spd	Brk Spd	Rel Spd
4	#	#	Stop	Time	of stop	of stop	Setpoint	kph	Setpoint
5				sec			kph	kph	kph
6									
7	101	1	1	7,1	09:41:12	10.09.2021	0,00	20,94	0,00
8	101	2	2	7,5	09:41:52	10.09.2021	0,00	23,11	5,58
9	101	3	3	4,9	09:42:19	10.09.2021	0,00	15,45	4,44
10	101	4	4	6,5	09:42:37	10.09.2021	0,00	25,98	7,22

	A	B	C	D	E
1					
2			brake_data_begin		
3	Sect	Stop	Stop	Stop	Time
4	#	#	Stop	Time	of stop
5				sec	
6					
7	0050:0001	1		0 30	11:45:48
8	0050:0002	2		0 300	11:46:20
9	0101:0001	1		0 6,41	11:51:40
10	0101:0002	2		0 7,45	11:52:20
11	0101:0003	3		0 4,47	11:52:47
12	0101:0004	4		0 6,5	11:53:05
13	0101:0005	5		0 3,46	11:53:31
14	0101:0006	6		0 9,39	11:53:42
15	0101:0007	7		0 6,37	11:54:15
16	0101:0008	8		0 5,47	11:56:20
17	0101:0009	9		0 6,48	11:56:36
18	0101:0010	10		0 6,43	11:57:03
19	0101:0011	11		0 5,41	11:57:23
20	0101:0012	12		0 4,65	11:57:46
21	0101:0013	13		0 4,44	11:58:04
22	0101:0014	14		0 4,42	11:59:28
23	0101:0015	15		0 3,41	11:59:35

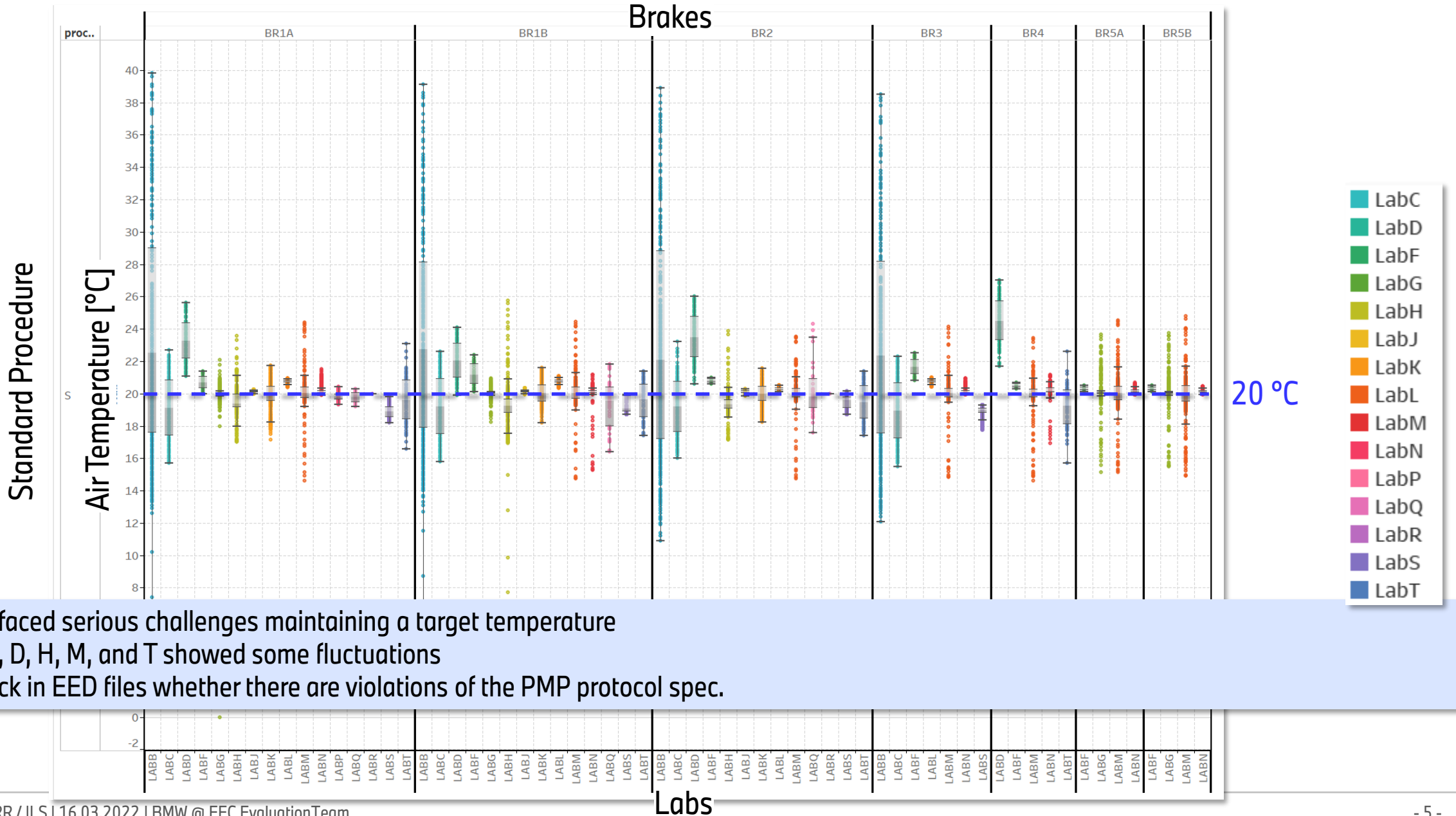
- New file versions V1, V2... created in close exchange with labs and Theo, mostly done by Theo

EEC FILES: DATA DELIVERED



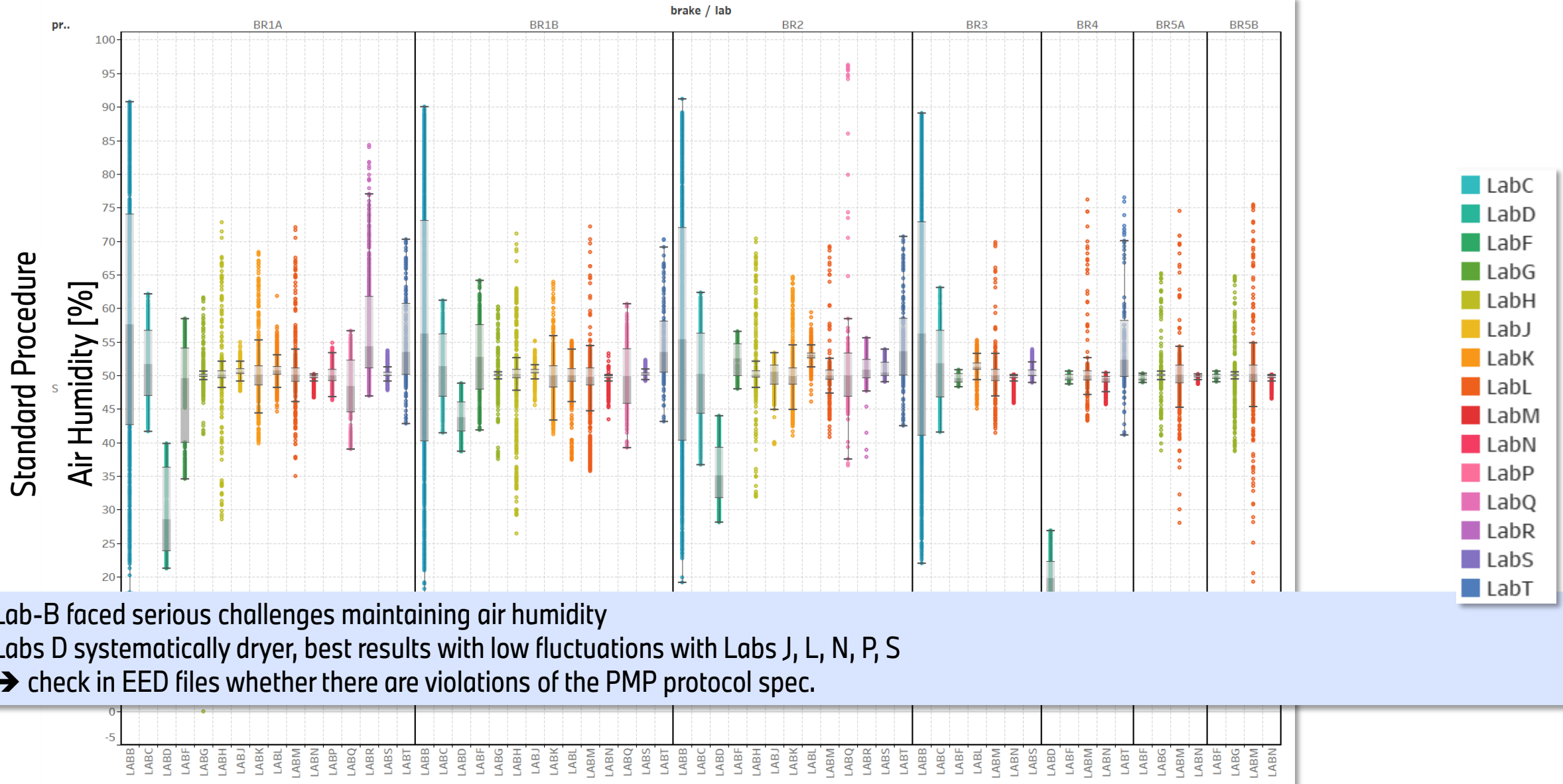
- 75 EEC Files received
- Equal amount of files from all labs had to be revised:
 - cooling sections removed to create the revised versions (V1 / V2... V5).
 - Additionally, negative and zero values were removed and substituted by empty cells not to compromise the statistical analysis.

EEC FILES: AIR TEMPERATURES PER LAB



- Lab-B faced serious challenges maintaining a target temperature
- Labs C, D, H, M, and T showed some fluctuations
- ➔ check in EED files whether there are violations of the PMP protocol spec.

EEC FILES: AIR HUMIDITY

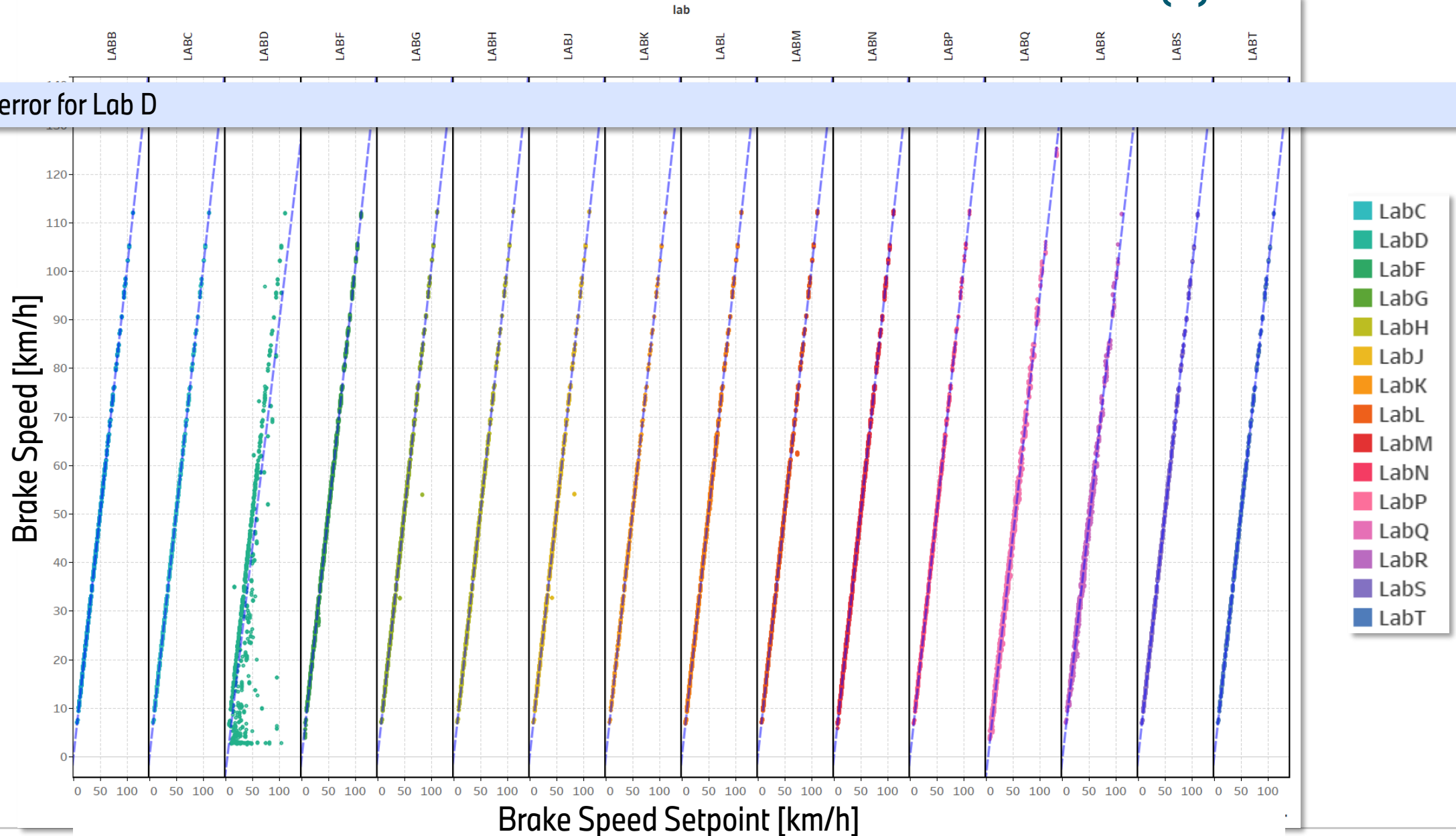


- Lab-B faced serious challenges maintaining air humidity
- Labs D systematically dryer, best results with low fluctuations with Labs J, L, N, P, S
 ➔ check in EED files whether there are violations of the PMP protocol spec.

EEC FILES: CORRELATION OF BRAKE SPEED PROFILE VS. SETPOINT (1)

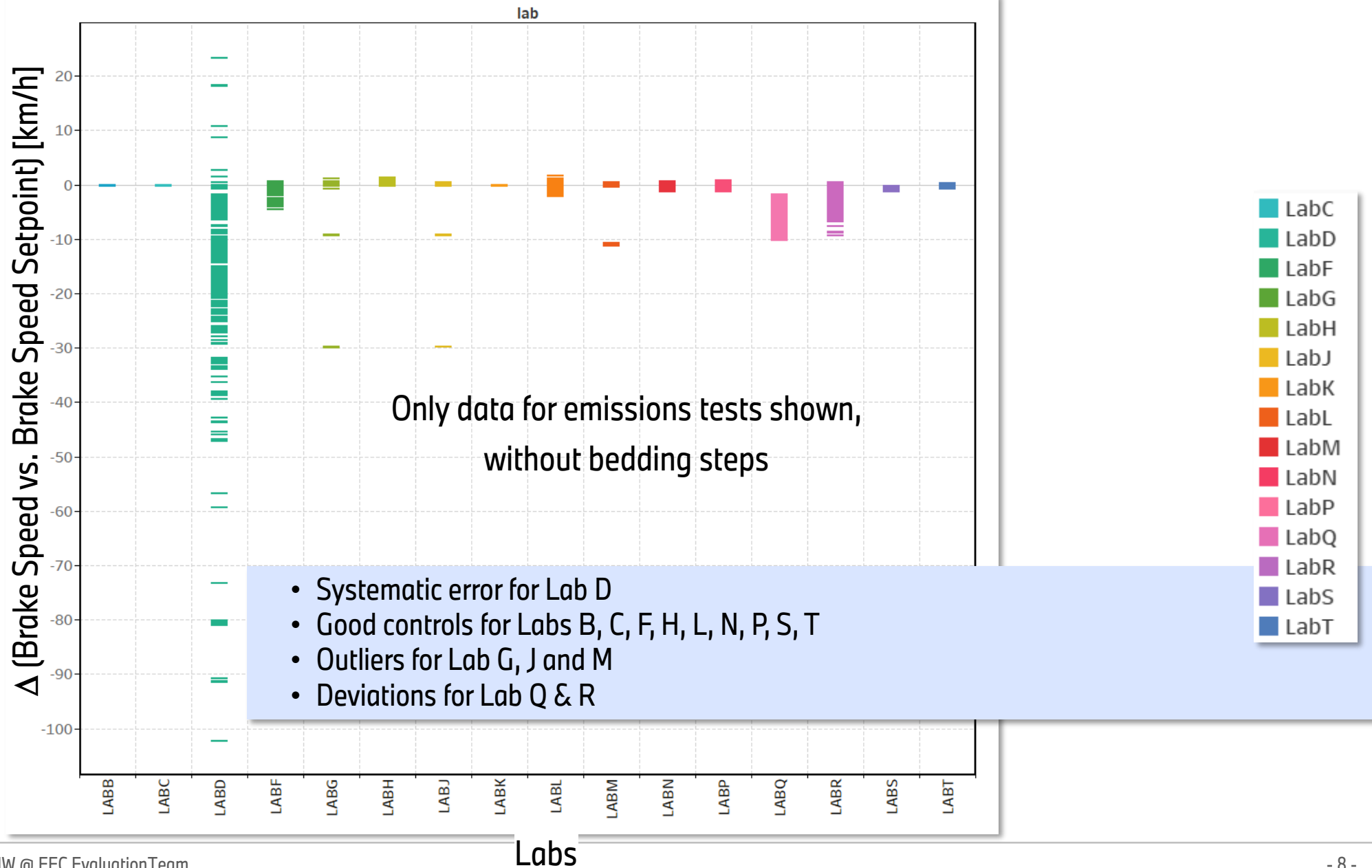
- Systematic error for Lab D

Standard Procedure



EEC FILES: CORRELATION OF BRAKE SPEED PROFILE VS. SETPOINT (2)

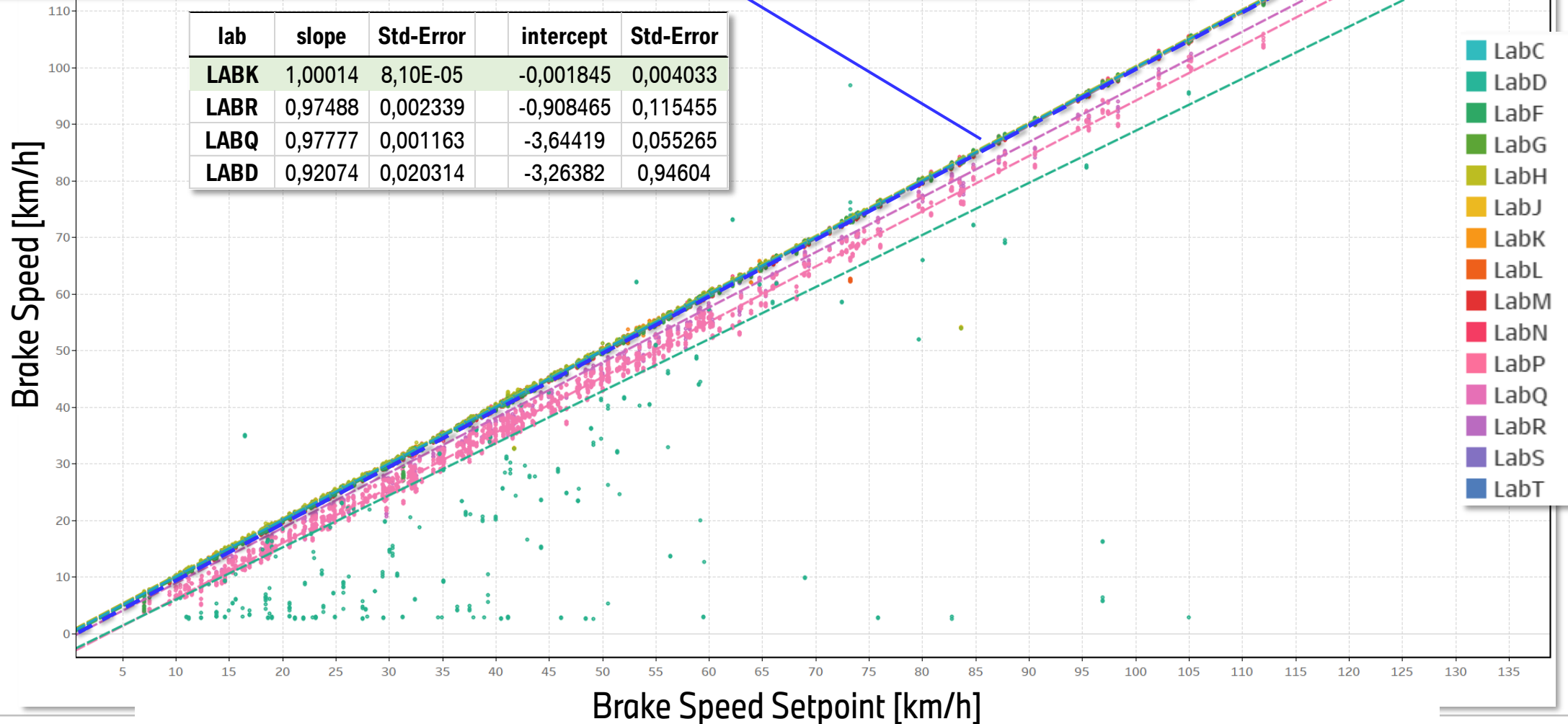
Standard Procedure



EEC FILES: CORRELATION OF BRAKE SPEED PROFILE (3)

- Perfect brake speed control would result in an **ideal bisectrix** in the plot (fitting line slope = 1, intercept = 0)
- Systematic error for Lab D
- Good controls for Labs B, C, F, H, L, N, P, S, T
- Deviations for Lab Q & R → see also fitting curve parameters

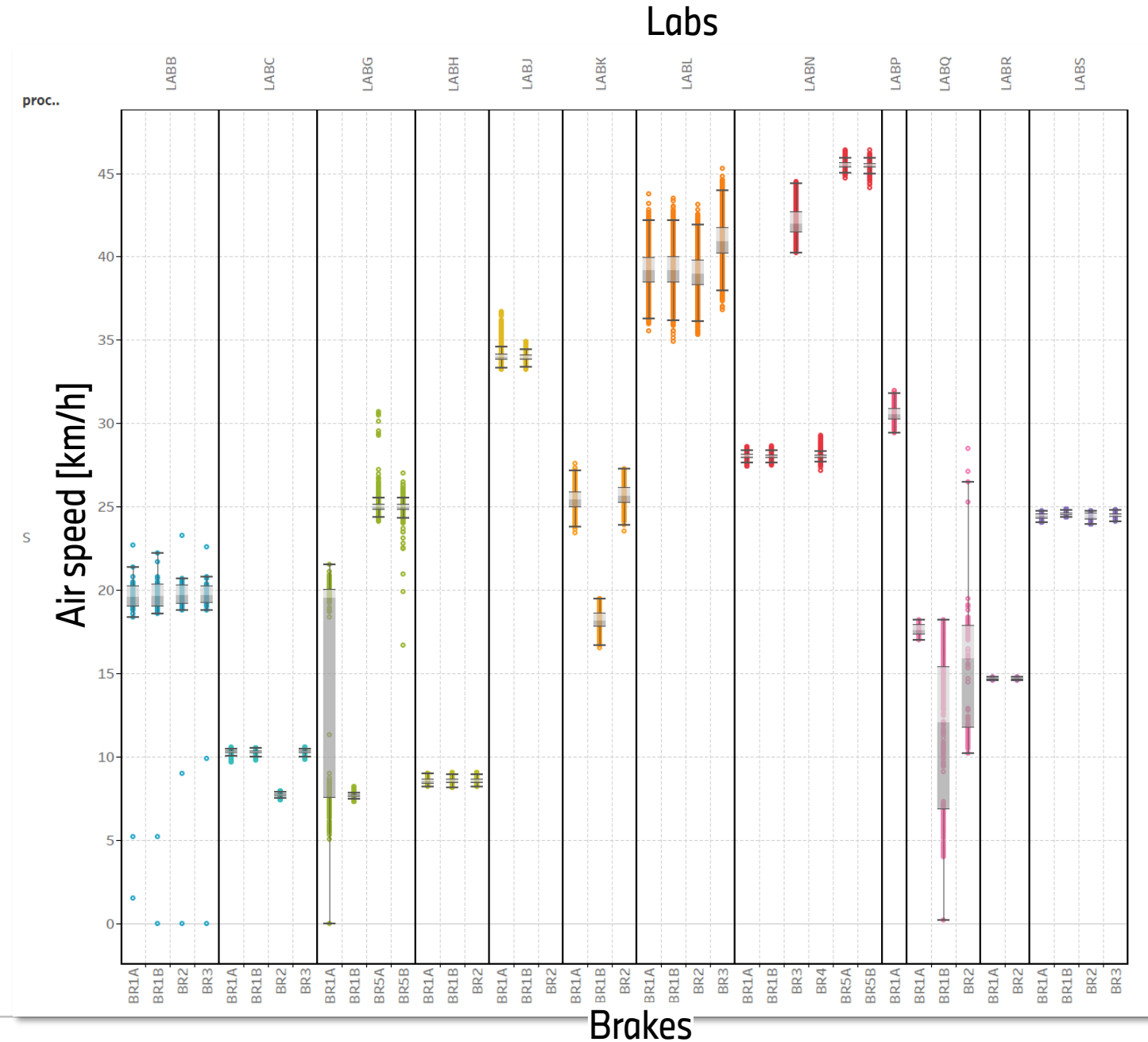
Standard Procedure



EEC FILES: AIR SPEED

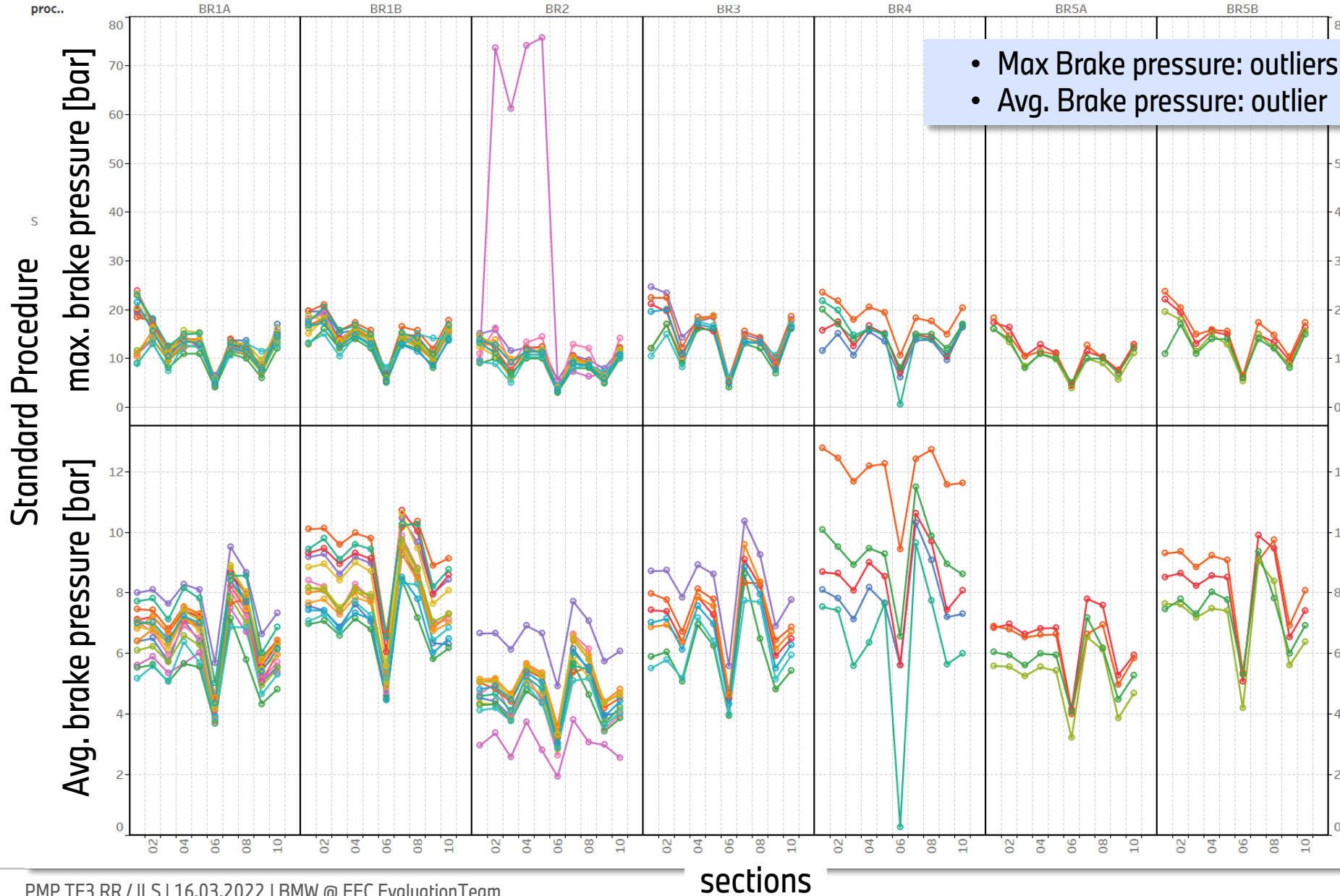
- Deviations for Lab B
- High variations for Lab G & Q
- Bigger variations for Lab L

Standard Procedure



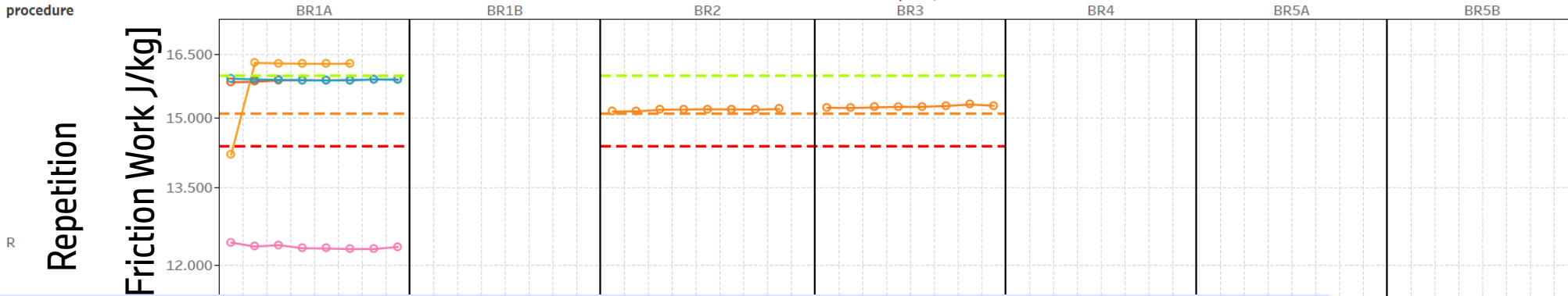
EEC FILES: BRAKE PRESSURES

Brakes

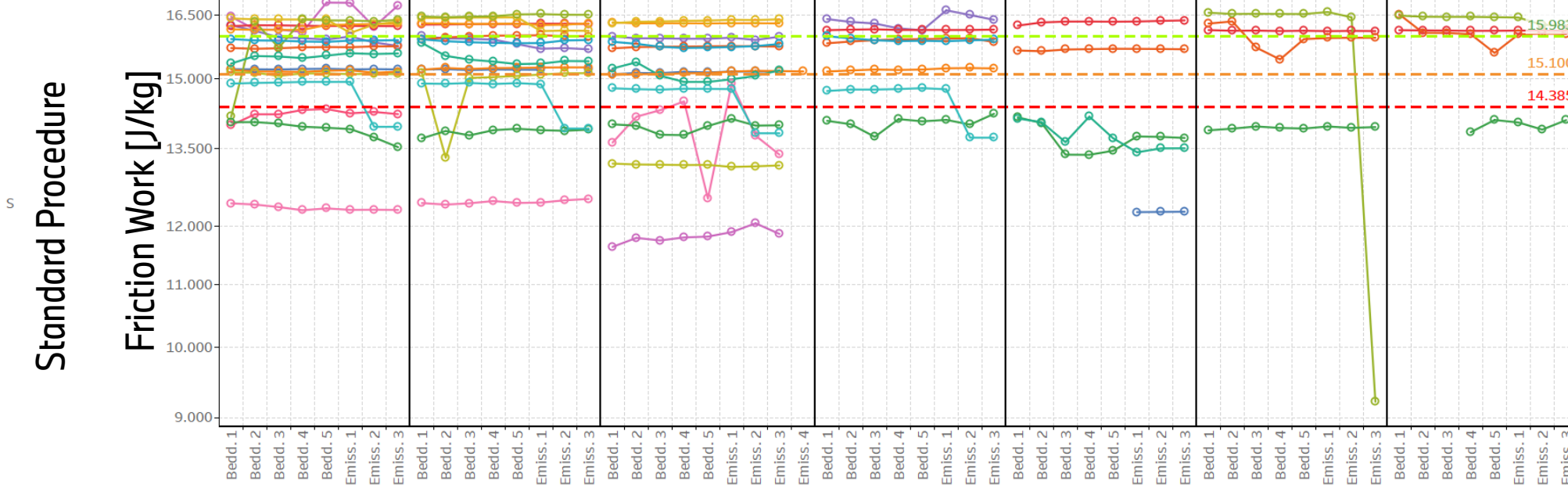


- Max Brake pressure: outliers for Lab R, Brake 2
- Avg. Brake pressure: outlier for Lab D, Brake 4

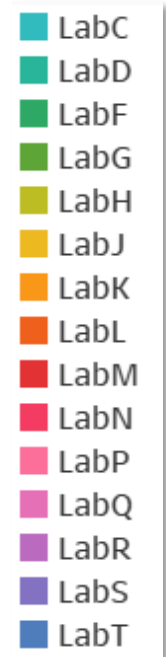
EEC FILES: FRICTION WORK



- Some labs above theoretical value of 15.983 J/kg: Labs G, J, K, (M), N, R, S
- Some labs in 5 % range deviation: Labs B, D, (H), L, M, (S), T
- Some labs n 10 % range deviation: Lab C, (D), H, (Q)
- Labs > 10 % of range deviation: Lab (C), F, (G), (H), P, Q, (R), (T)

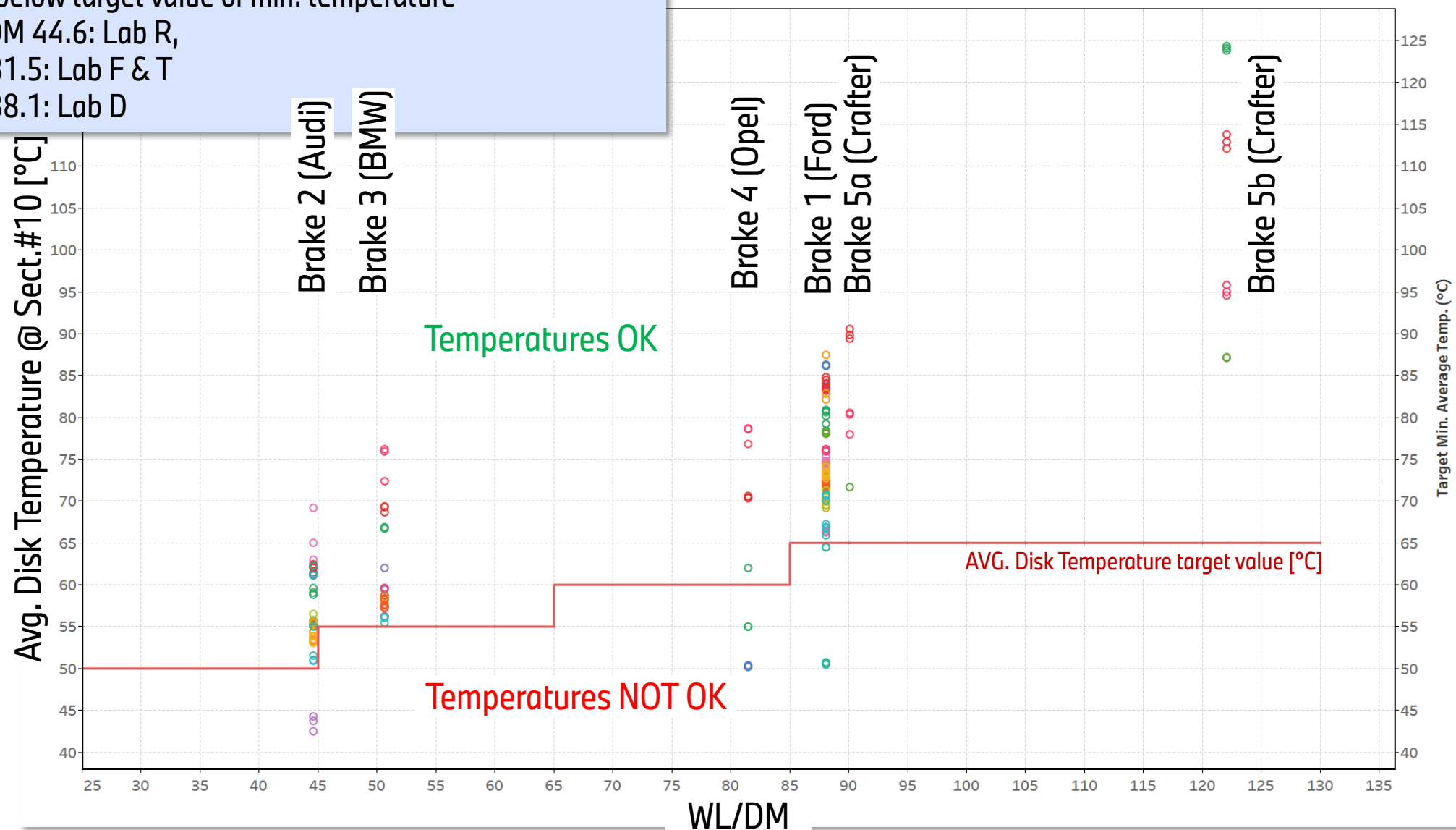


Nominal value



EEC-FILES: AVERAGE DISK TEMPERATURES OF SECTION #10

- Some labs below target value of min. temperature
 - For WL/DM 44.6: Lab R,
 - WL/DM 81.5: Lab F & T
 - WL/DM 88.1: Lab D



EEC-FILES: DISK TEMPERATURES: FBT

- few labs below target value of min. FBT temperature
 - WL/DM 88.1: Lab R
- several labs above target value of max. FBT temperature
 - WL/DM 81.5: Lab M & N
 - WL/DM 90.1: Lab F & M
 - **WL/DM 122.1: All measurements! Lab F, G, M, N**

