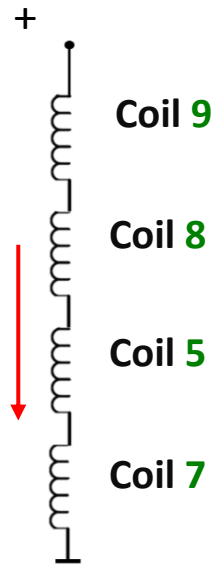
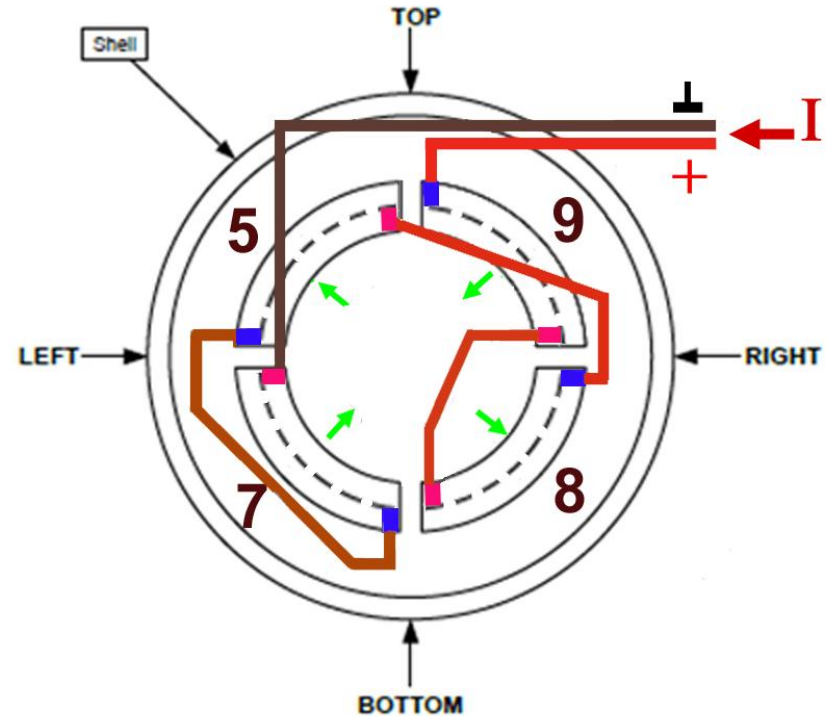
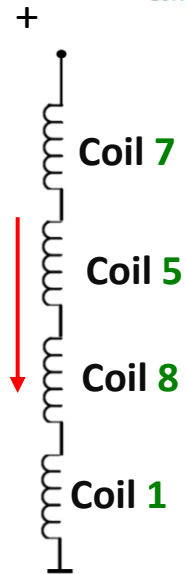
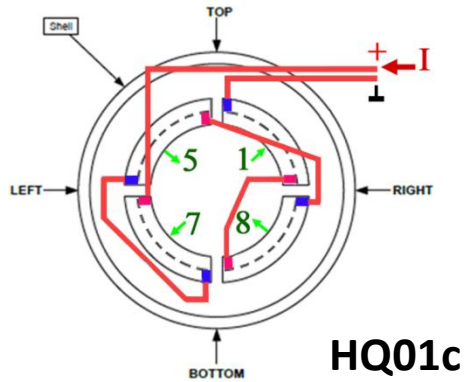


HQ01d quench performance

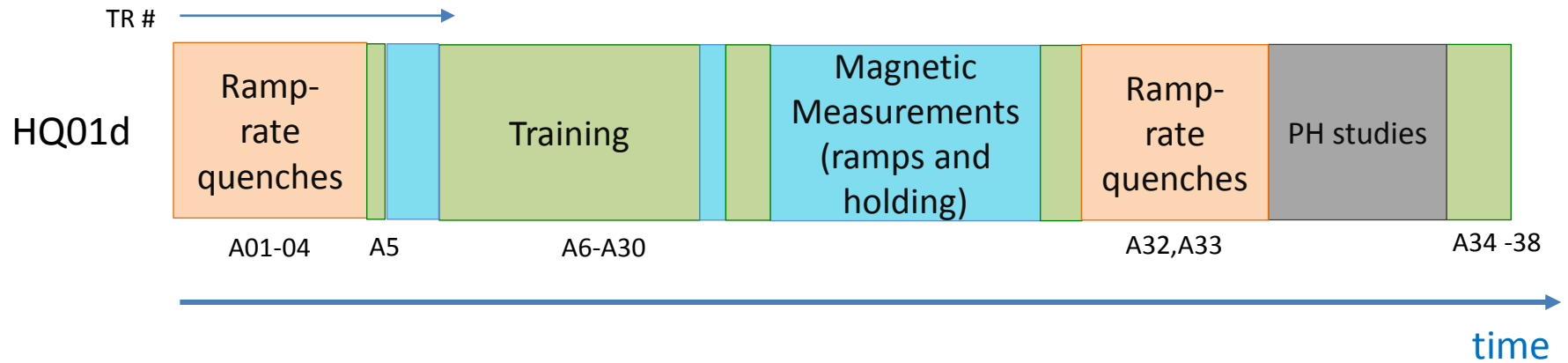
M. Marchevsky, LBNL

HQ01d magnet configuration



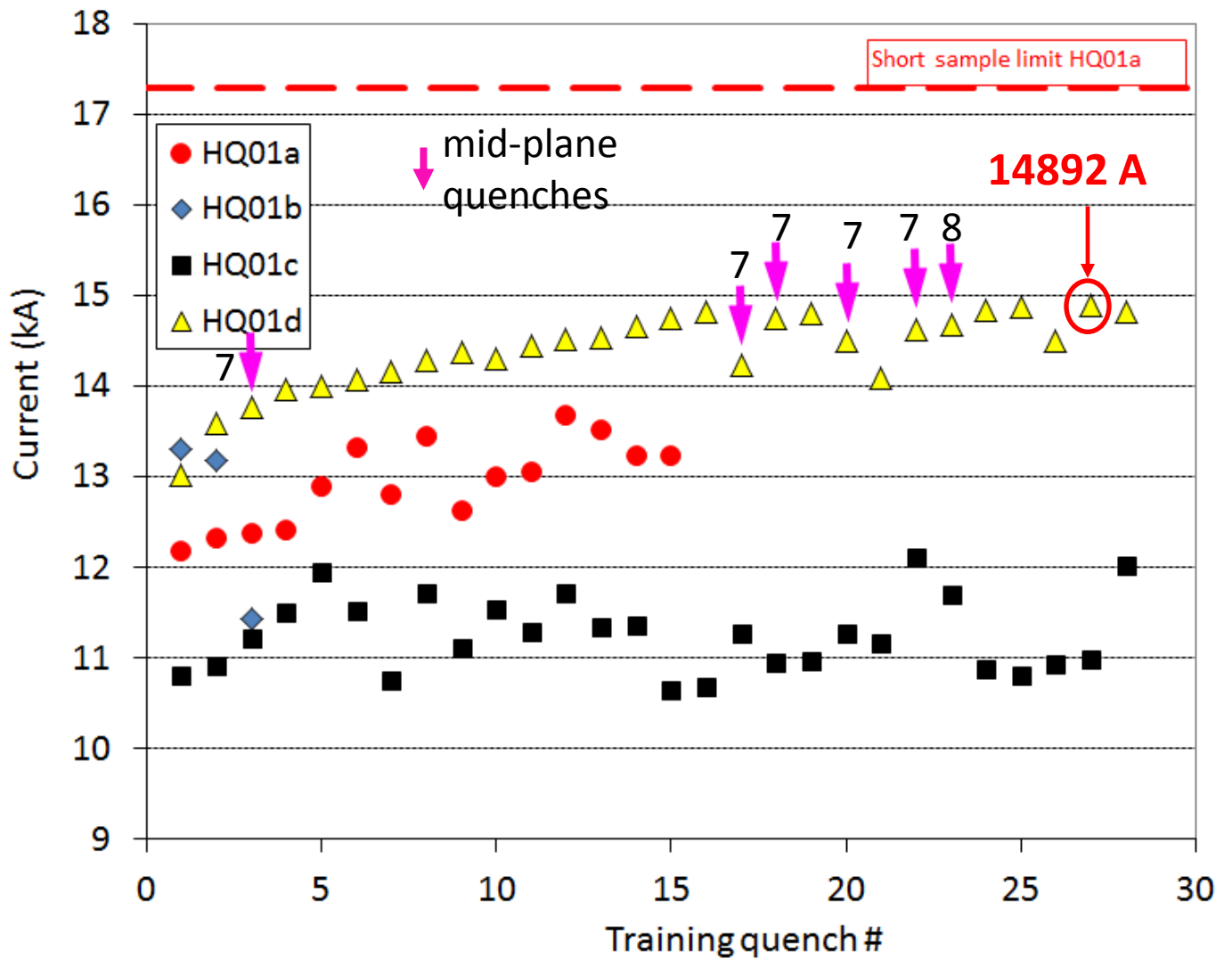
HQ01d coil arrangement is similar to HQ01c, but Coil 9 replaced Coil 1 and current polarity is reversed

Test timeline



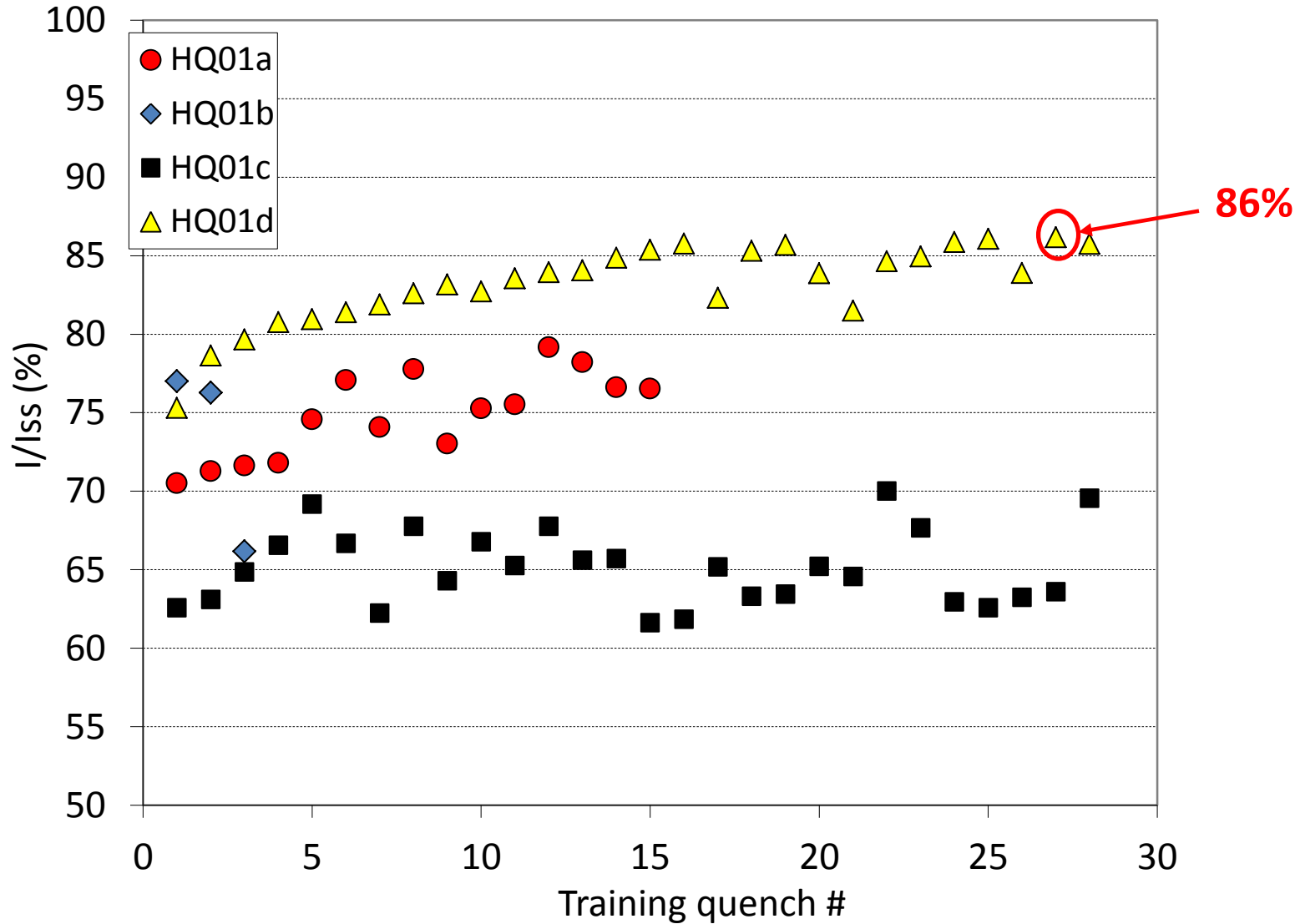
Training plot

Attempt #	Train. Q#
1	
2	
5	1
7	2
8	3
9	4
10	5
11	6
12	7
13	8
14	9
15	10
16	11
17	12
18	13
19	14
20	15
21	16
22	17
23	18
24	19
25	20
26	21
27	22
28	23
29	24
30	25
31	
32	
33	
34	26
36	27
38	28

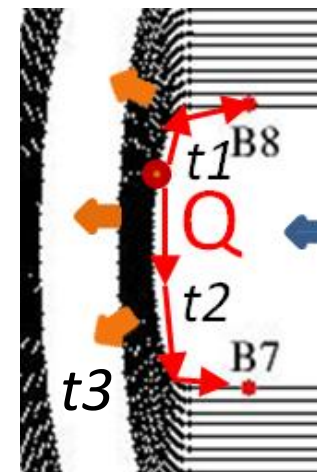
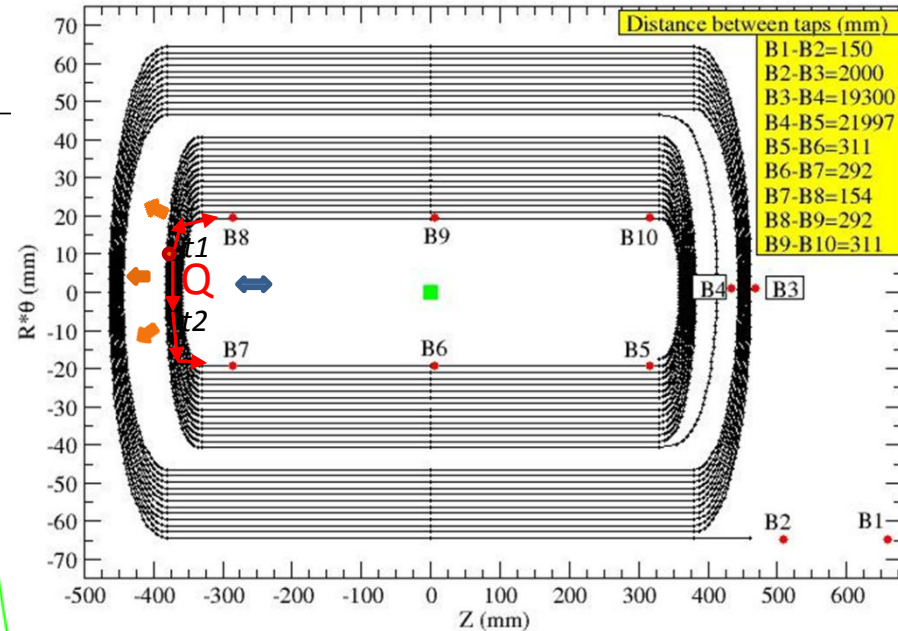
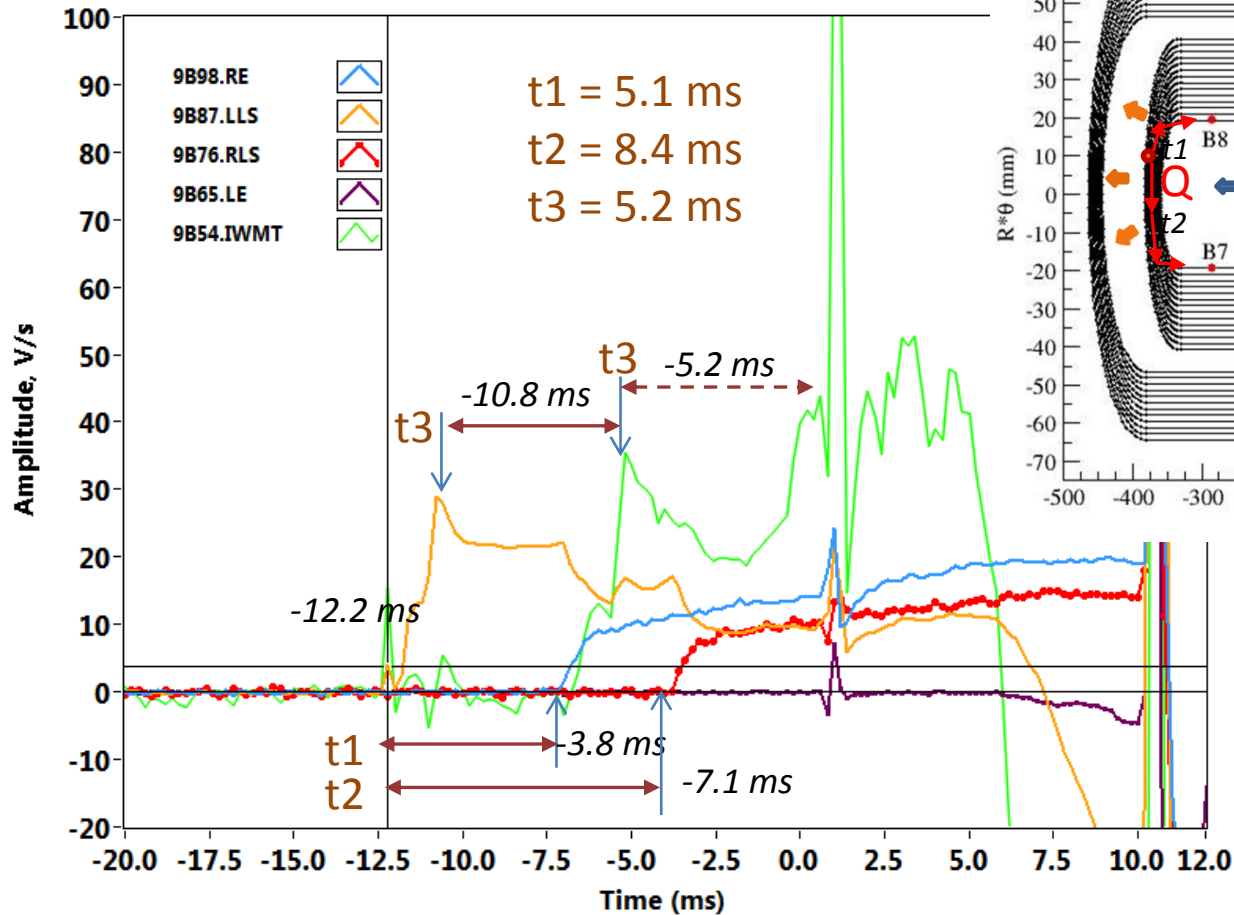


Training plot (Iss%)

Attempt #	Train. Q#
1	
2	
5	1
7	2
8	3
9	4
10	5
11	6
12	7
13	8
14	9
15	10
16	11
17	12
18	13
19	14
20	15
21	16
22	17
23	18
24	19
25	20
26	21
27	22
28	23
29	24
30	25
31	
32	
33	
34	26
36	27
38	28



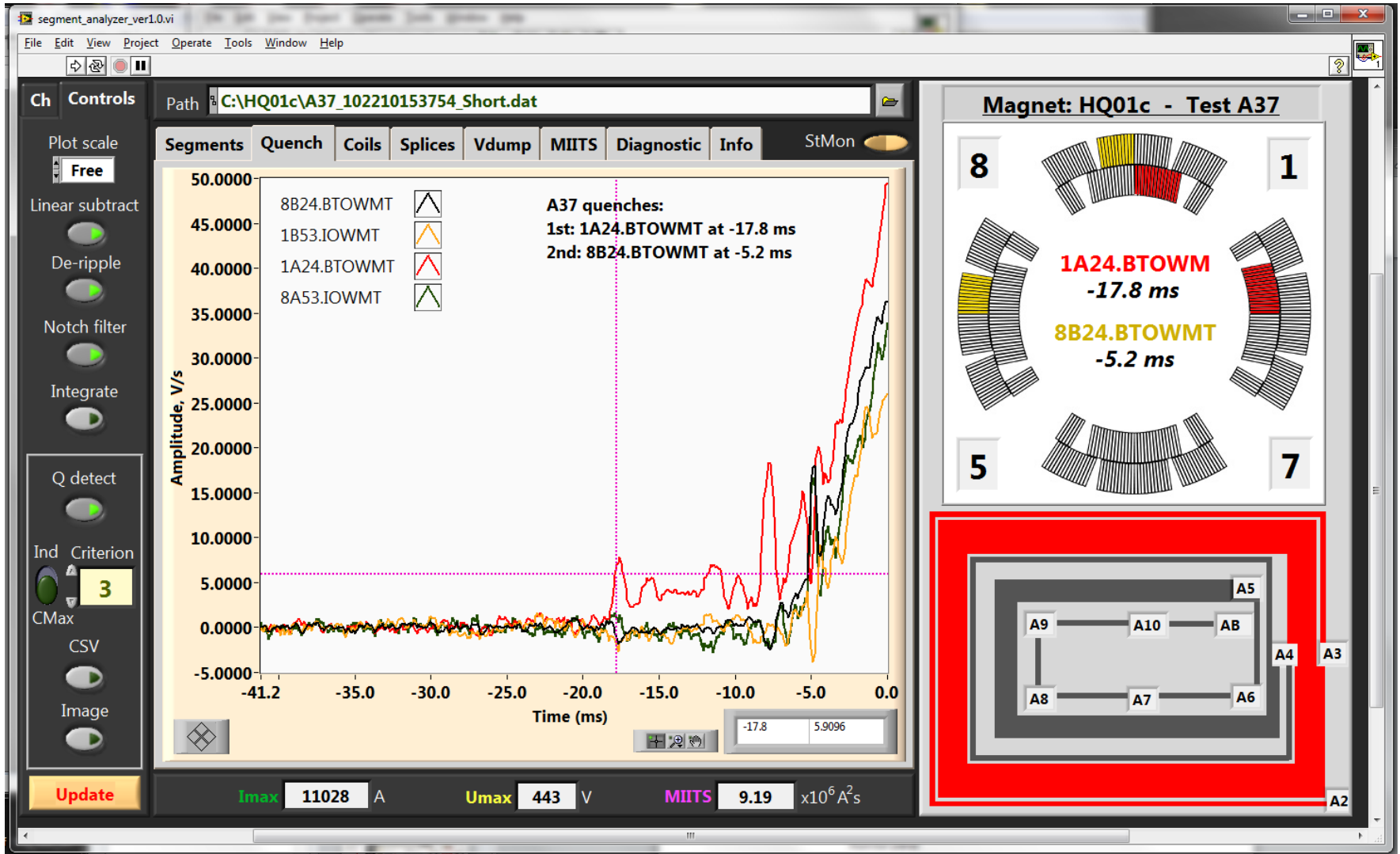
Quench propagation example (A15)



$$V_q = 154 \text{ mm} / (5.1 + 8.4) \text{ ms} = 11.4 \text{ m/s}$$

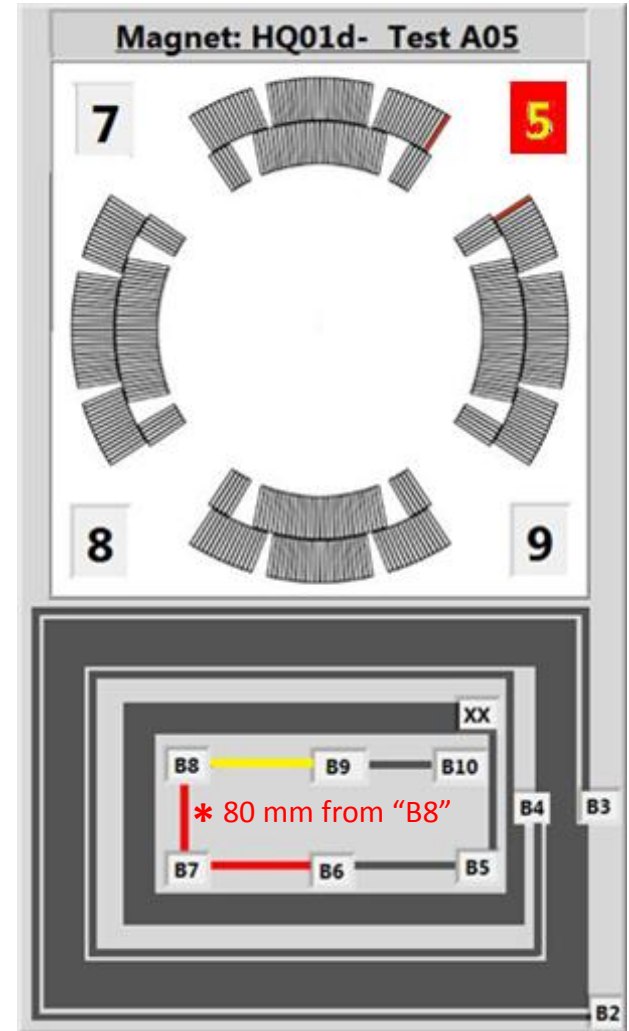
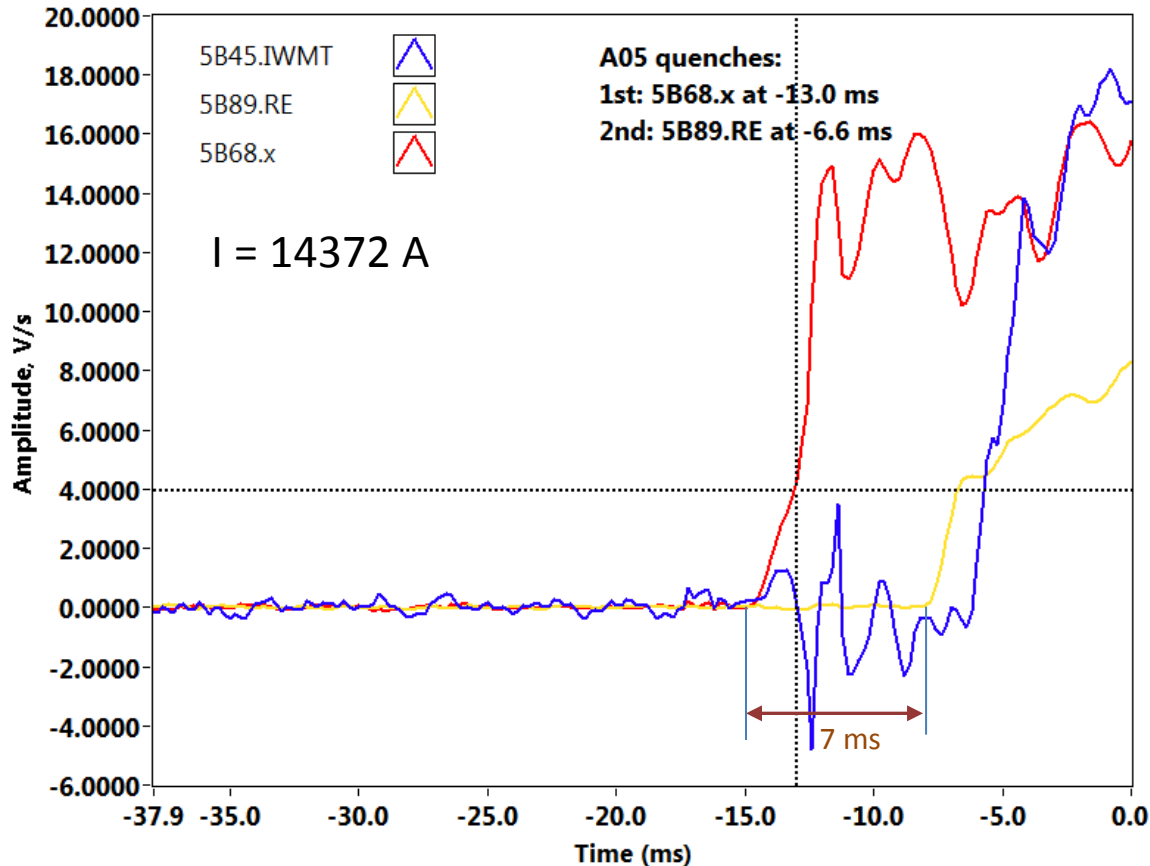
$$\tau_{t-t} = 5.2 \text{ ms}$$

Quench analyzer software

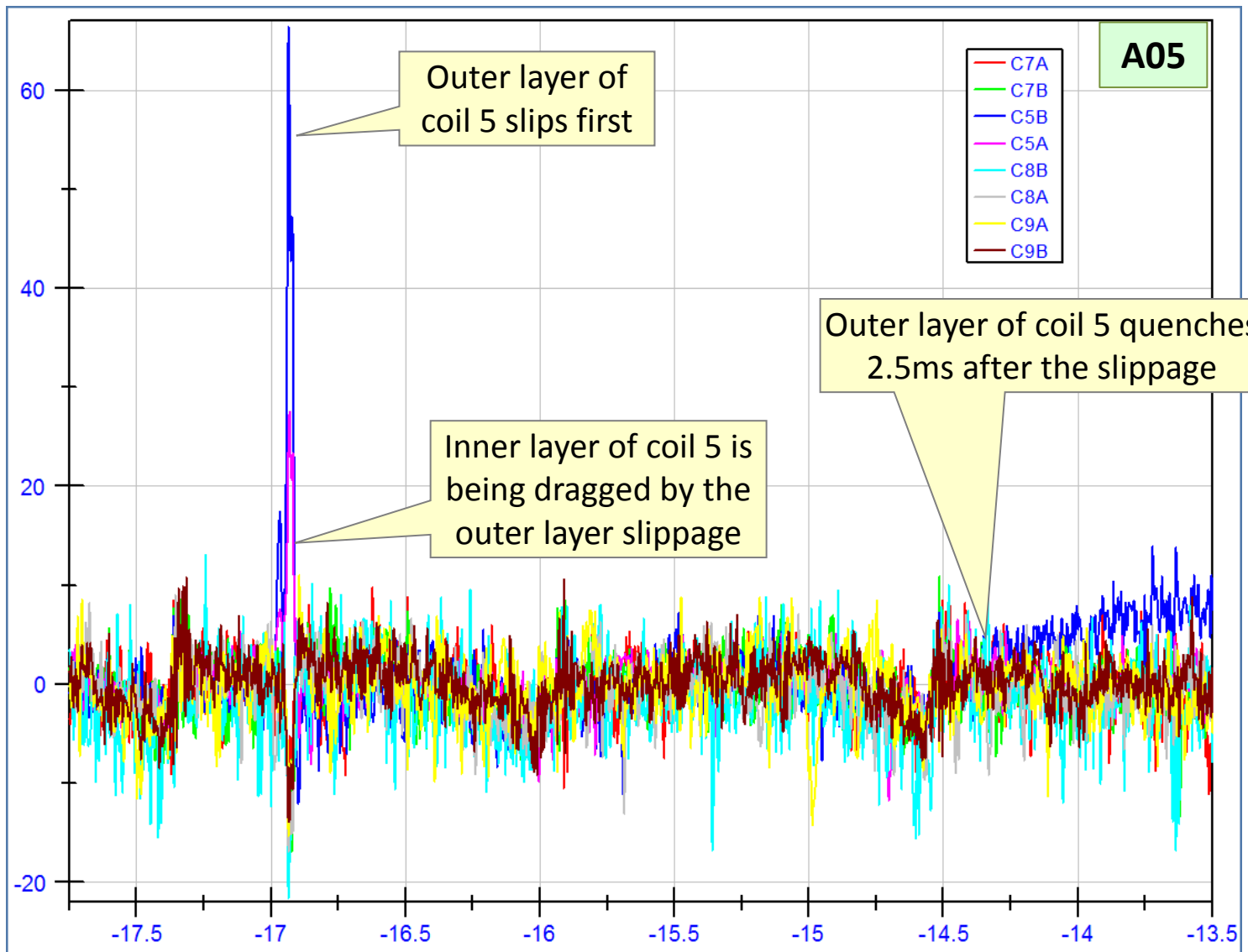


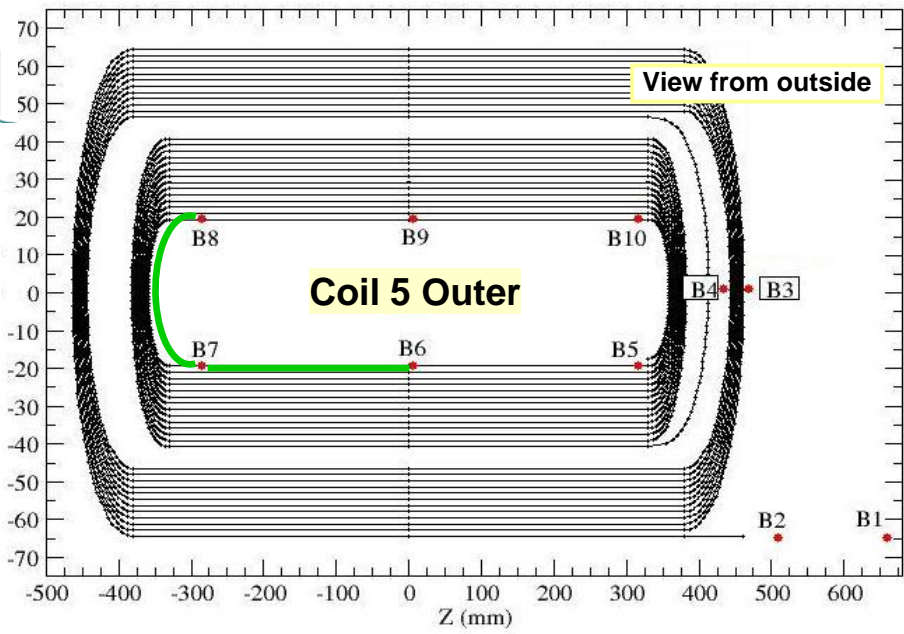
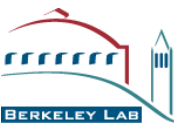
Pole, return end quench (A05)

1st training quench (50 A/s to 7 kA, then 20 A/s)



Initial quench at the pole turn 5B68, propagating into 5B89 and 5B45 multi-turn

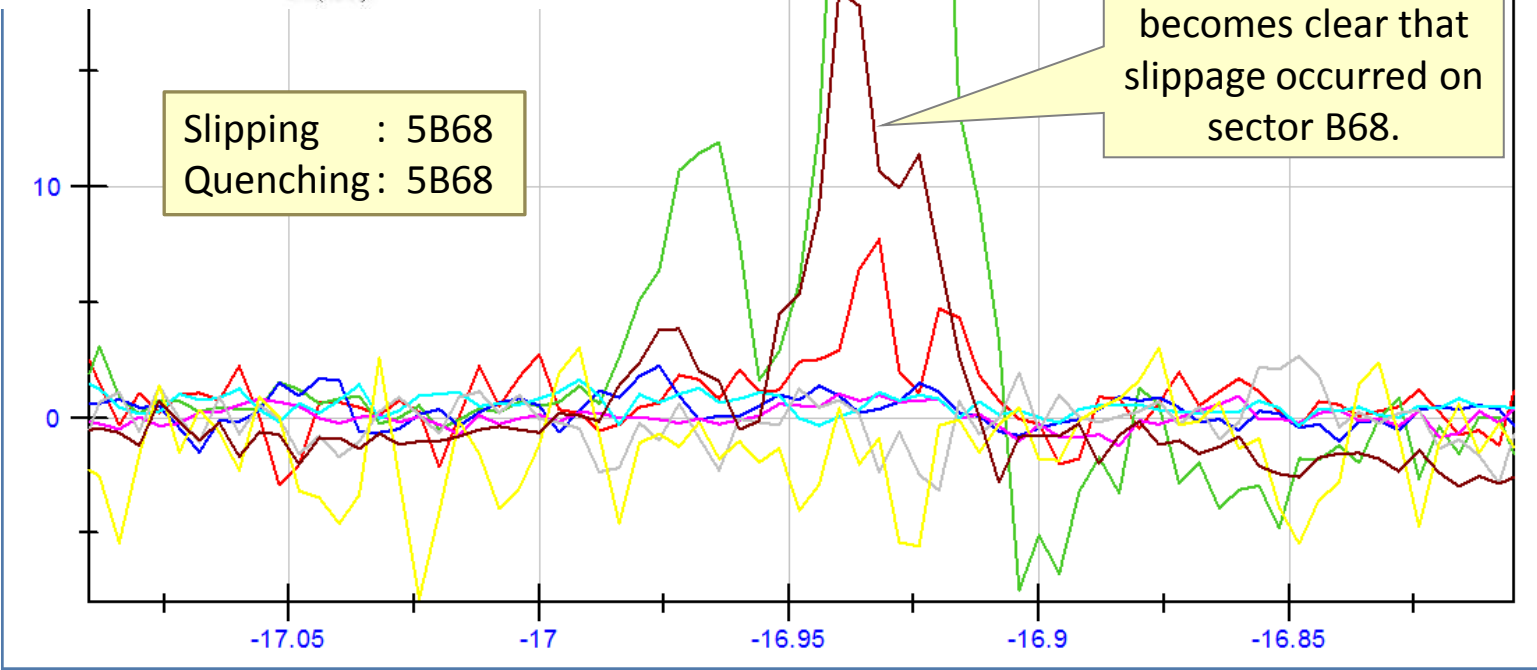




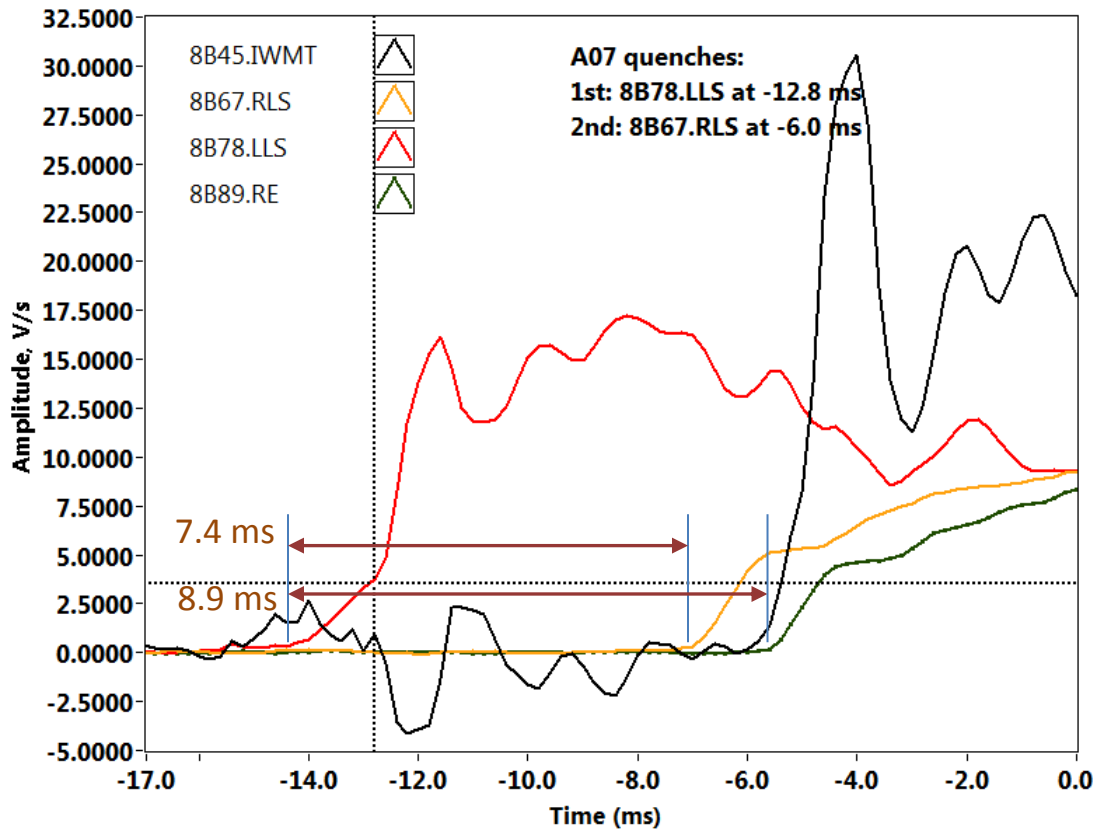
A05

- 5B34.OWMT
- 5B45.IVMT
- 5B56.LE
- 5B89.RE
- 5B910.LRS
- 5B10A10.Rmp
- 5B13.x
- 5B68.x

After normalizing by sector inductance, it becomes clear that slippage occurred on sector B68.



Pole, return end quench (A07)

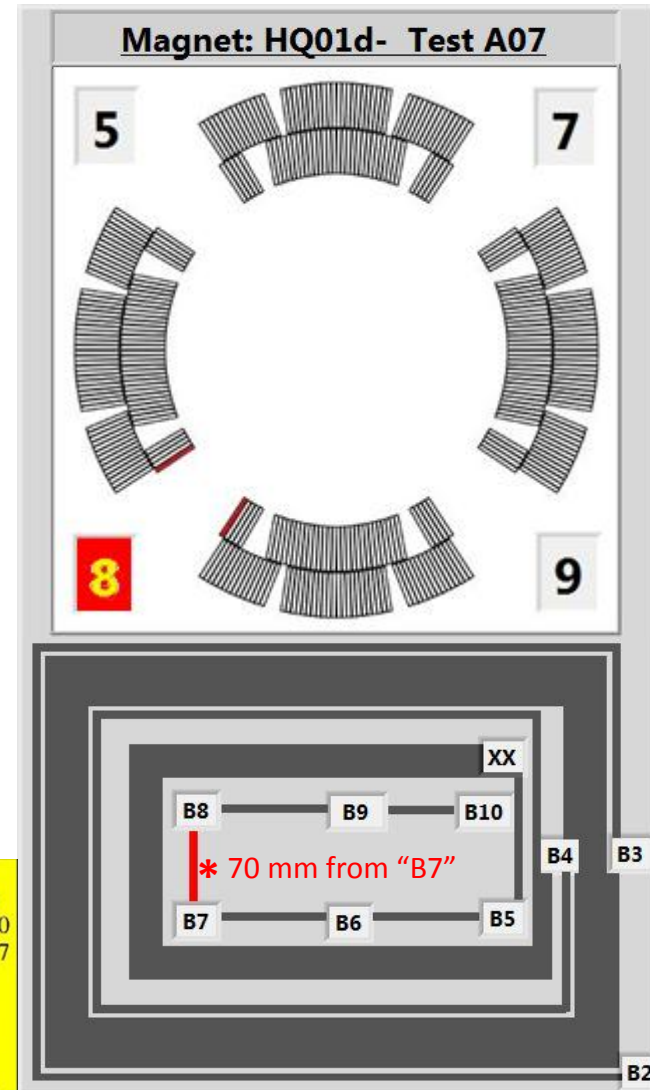


$I = 13572 \text{ A}$

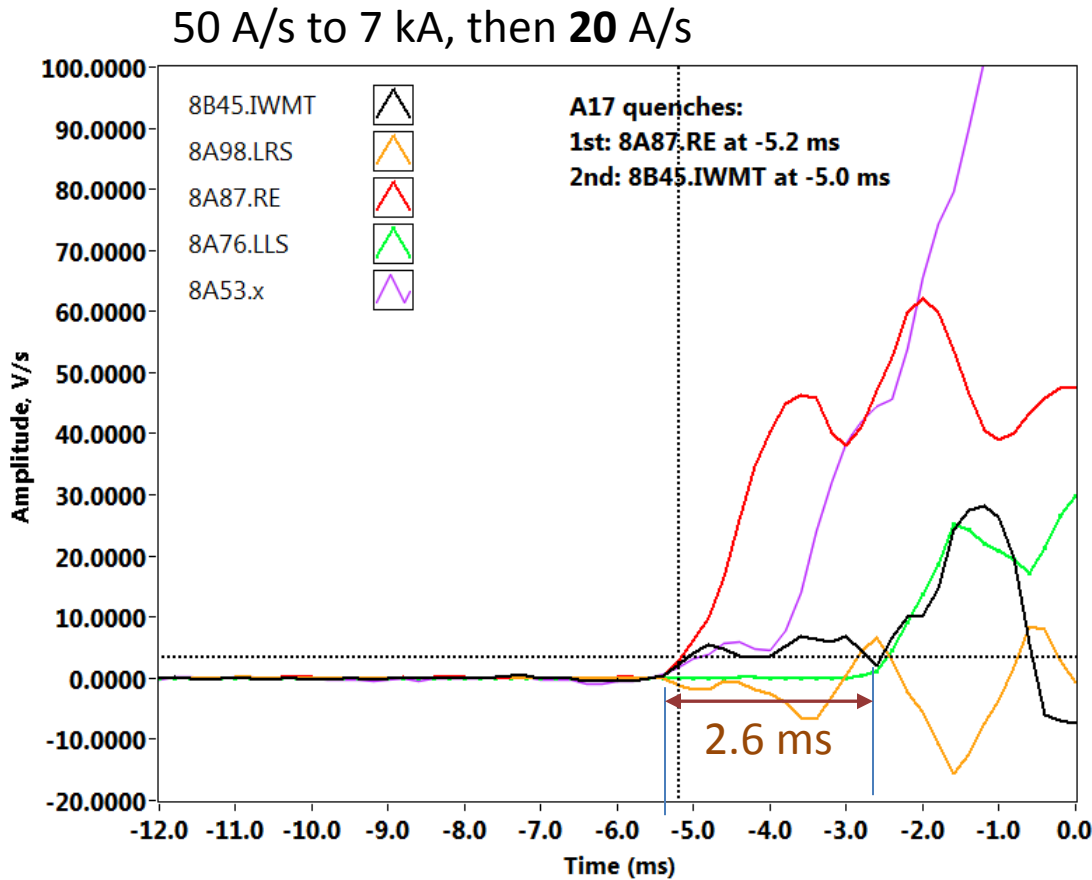
$MIITS = 12.21$

$V_1 = 154 \text{ mm} / (7.4 + 8.9) \text{ ms} = 9.4 \text{ m/s}$

- B1-B2=150
- B2-B3=2000
- B3-B4=19300
- B4-B5=21997
- B5-B6=311
- B6-B7=292
- B7-B8=154
- B8-B9=292
- B9-B10=311

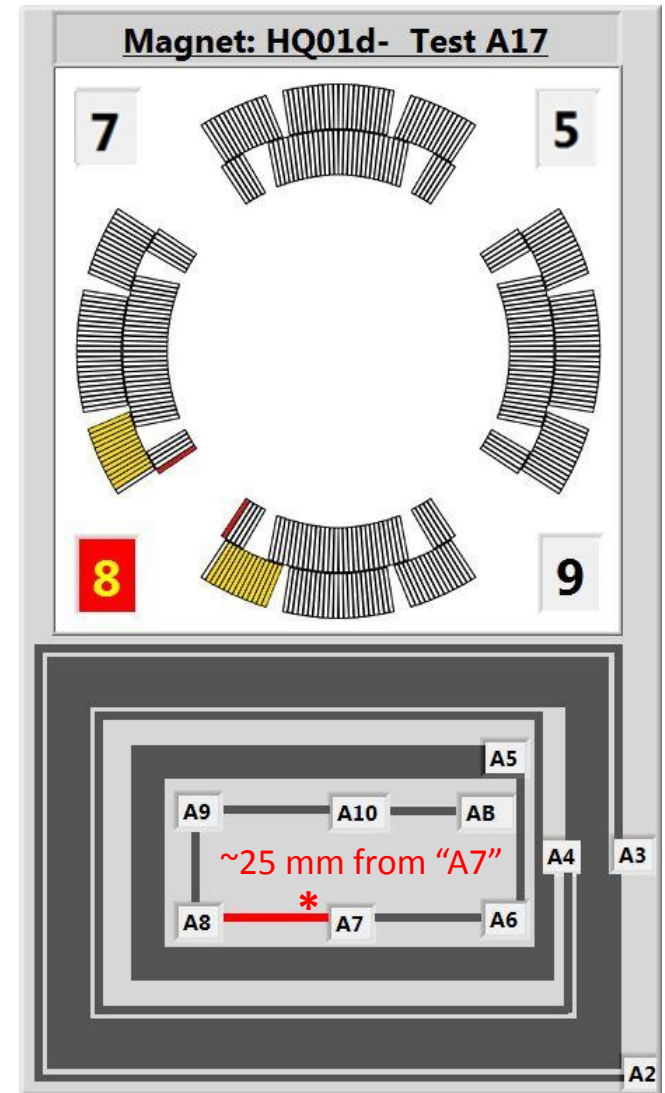


Pole, straight section quench (A17)



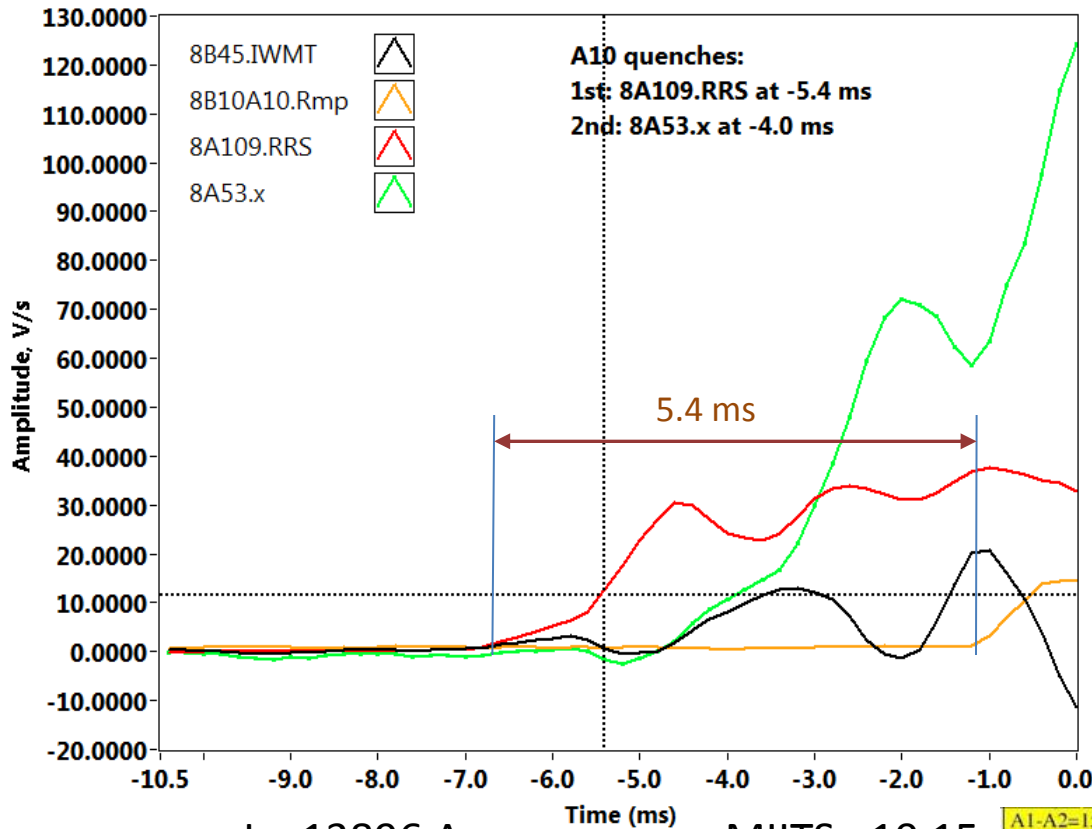
I = 14485 A

MIITS = 10.13



Pole-straight section quench (A10)

50 A/s to 7 kA, then 20 A/s

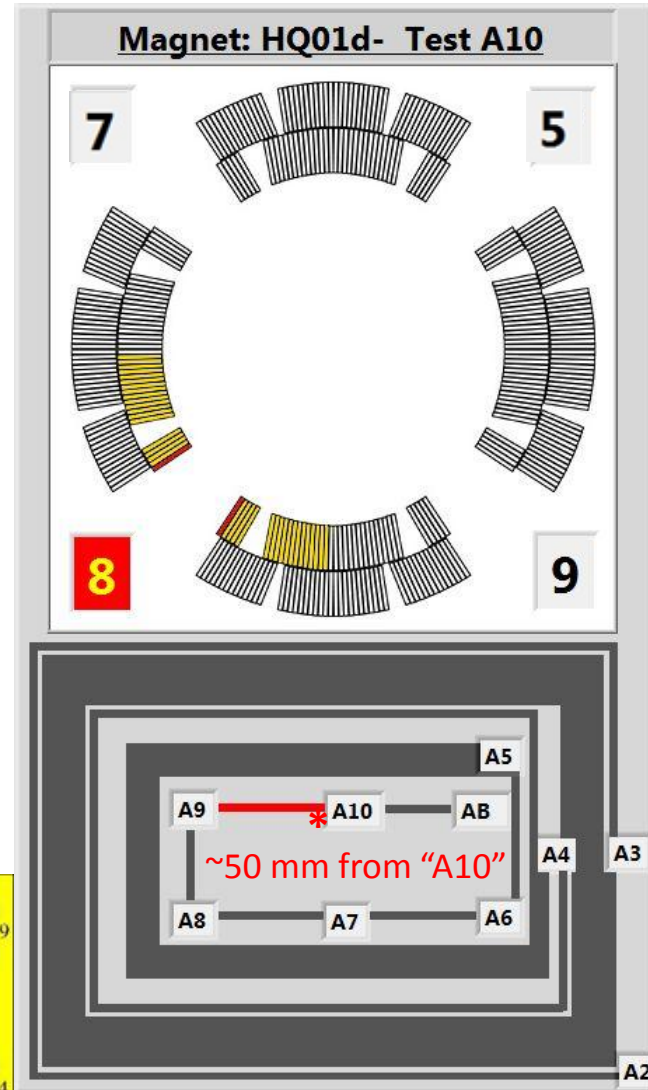


I = 13896 A

MIITS = 10.15

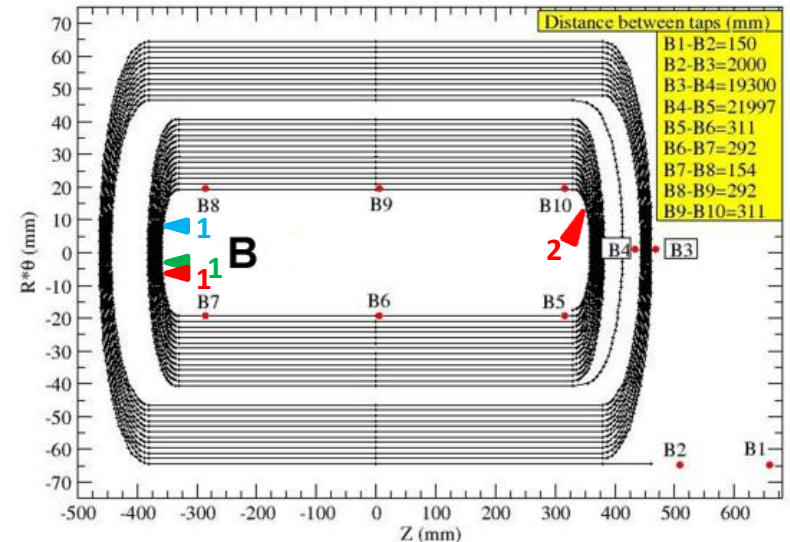
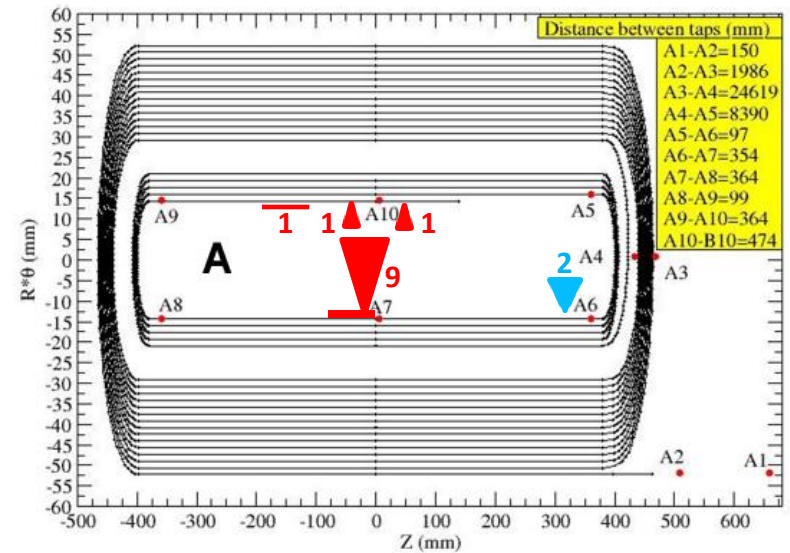
- A1-A2=150
- A2-A3=1986
- A3-A4=24619
- A4-A5=8390
- A5-A6=97
- A6-A7=354
- A7-A8=364
- A8-A9=99
- A9-A10=364
- A10-B10=474

(QL based on ~ 9.4 m/s velocity)



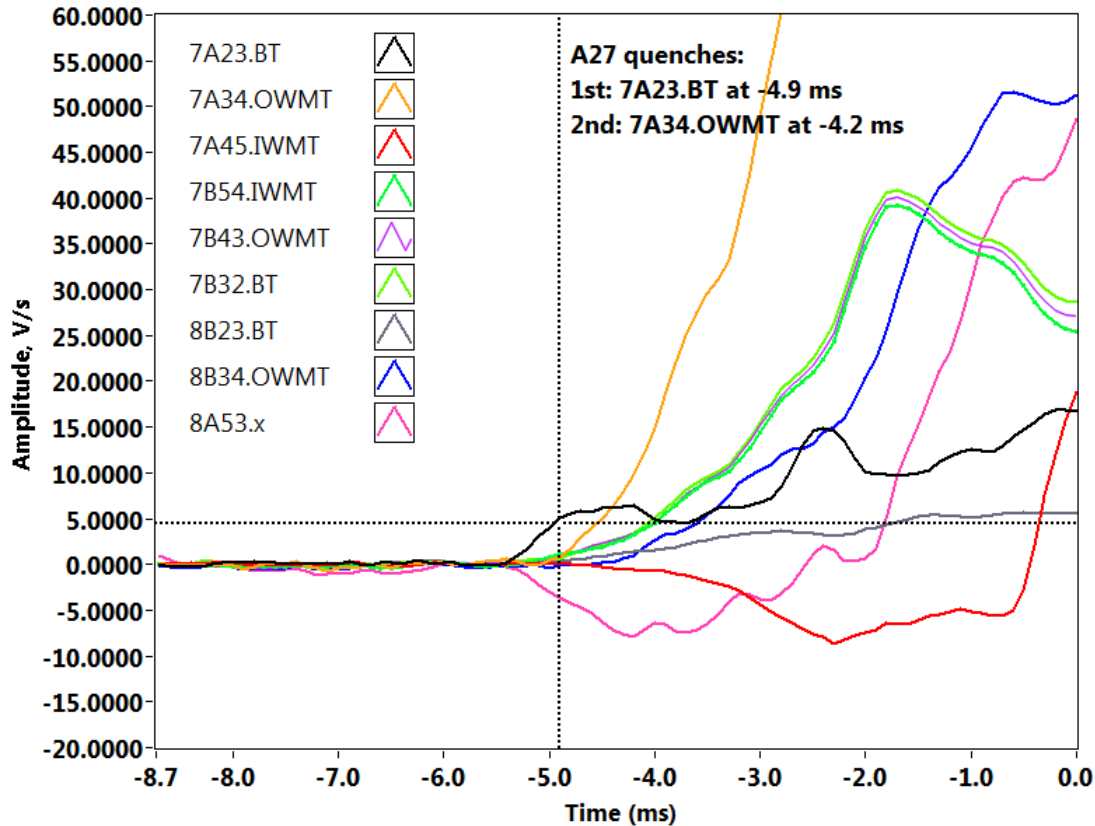
HQ01d pole quenches summary

A#	Coil	Layer	Section	Segment	Exact location
5	5	B	RE	78	80 mm from B8
7	8	B	RE	78	70 mm from B7
9	8	A	RE	78	30 mm from A7
10	8	A	Straight	910	50 mm from A10
11	5	A	?	54	First outer turn of the MT
12	8	A	Straight	910	N/D
13	8	AB	Ramp	1010	51 mm from A10
14	8	A	Straight	78	21 mm from A7
15	9	B	RE	78	58 mm from B8
16	8	A	Straight	78	23 mm from A7
17	8	A	Straight	78	25 mm from A7
18	9	A	Straight	67	38 mm from A6
19	8	A	Straight	78	19 mm from A7
20	8	A	Straight	910	20 mm from A10
21	8	A	Straight	Vt 7	At A7
24	8	A	Straight	Vt 7	At A7
26	8	AB	Ramp (LE)	1010	28 mm from B10
29	8	A	Straight	910	24 mm from A10
34	8	AB	Ramp (LE)	1010	38 mm from B10
36	8	A	Straight	Vt 7	At A7
38	9	A	Straight	65	34 mm from A6



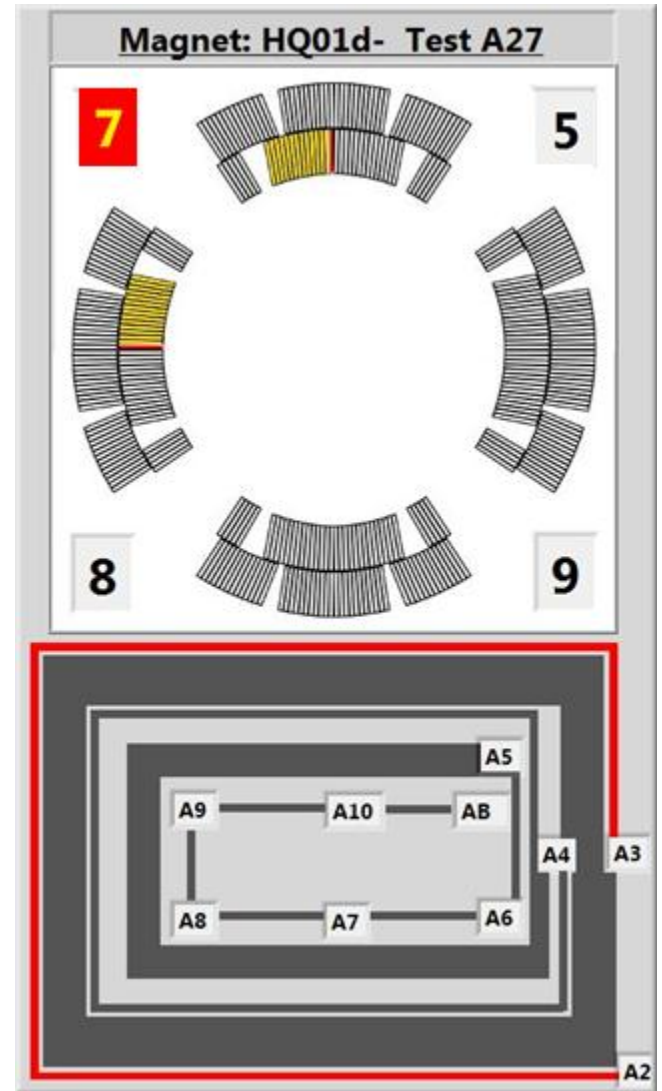
Mid-plane quench (A27)

50 A/s to 7 kA, then 20 A/s



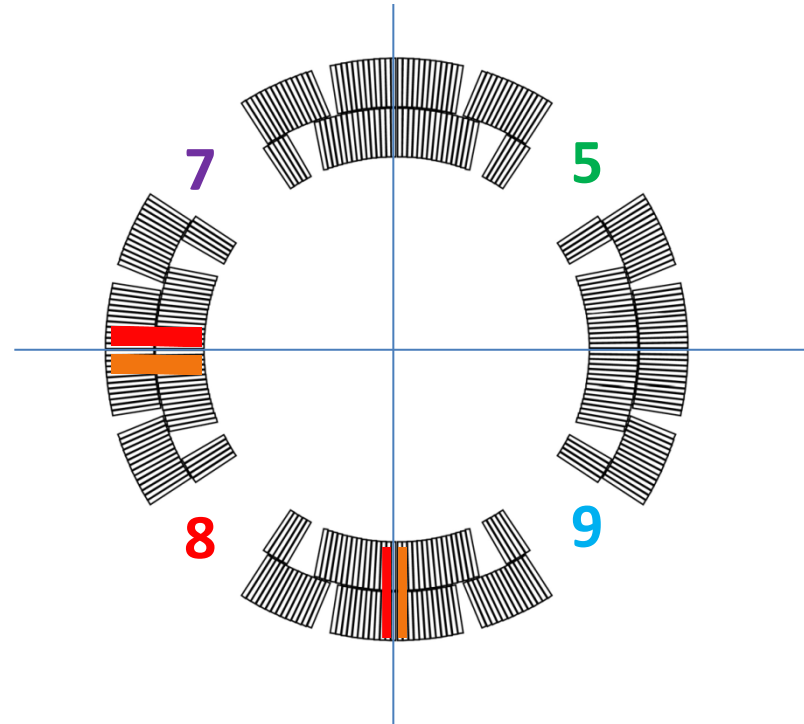
I = 14612 A

MIITS = 10.11



HQ01d mid-plane quenches summary

A#	First Coil	Second Coil
8	7	8
22	7	8
23	7	8
25	7	8
27	7	8
28	8	9
32*	8	9
33**	8	9

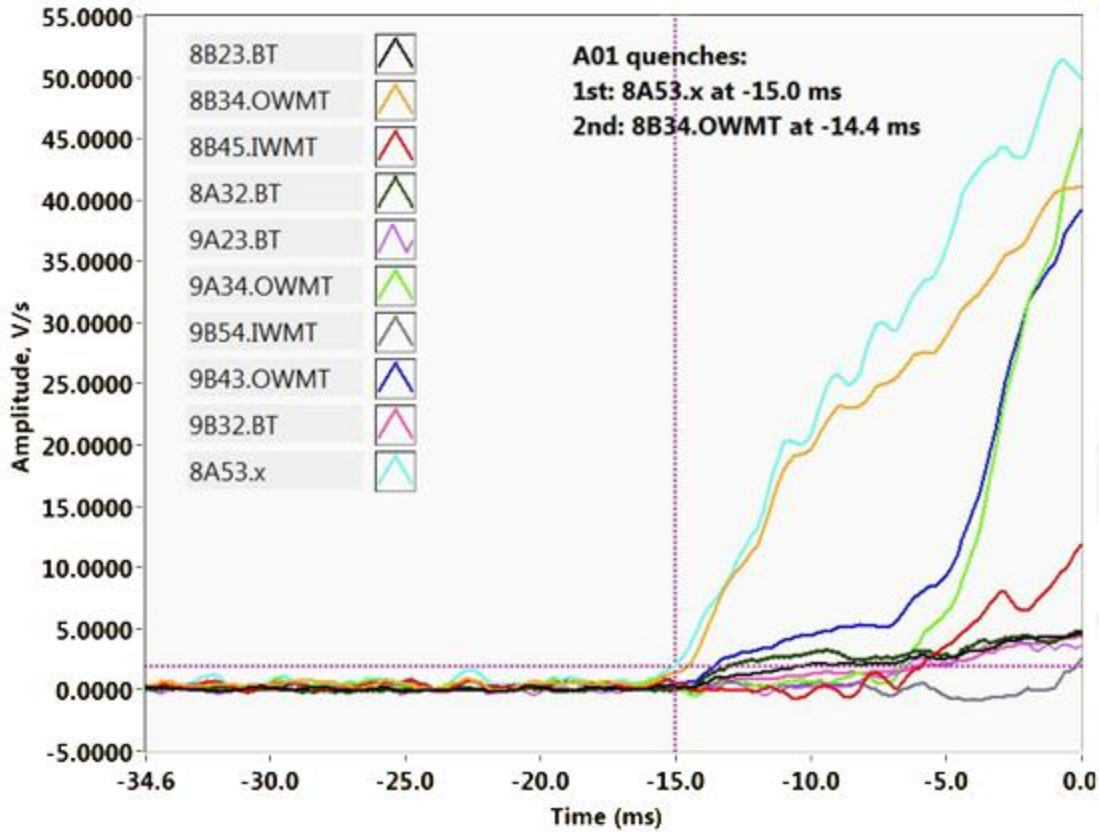


* Ramp at 50 A/s

** Ramp at 35 A/s

Fast ramp, mid-plane quench (A01)

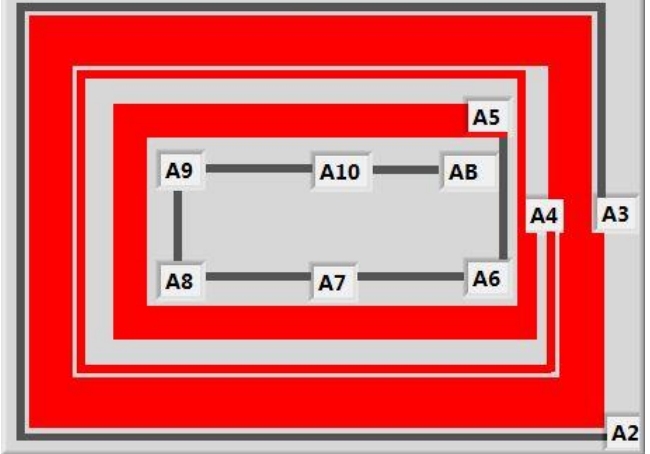
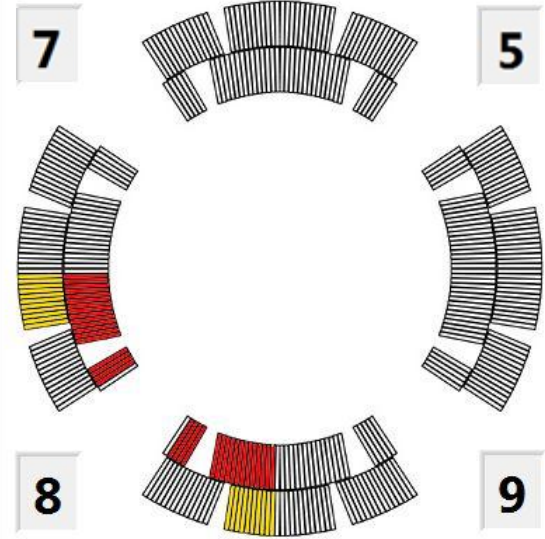
200 A/s



I = 5719 A

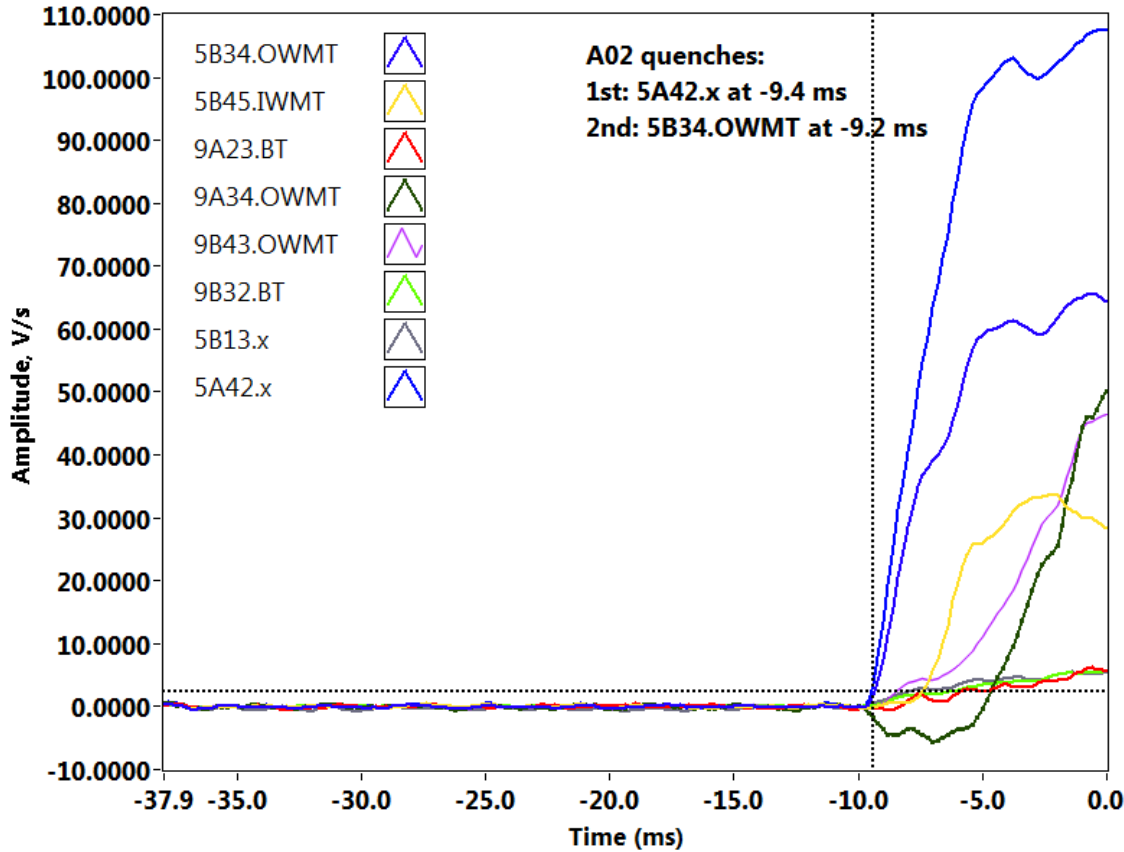
MIITS = 3.19

Magnet: HQ01d- Test A01



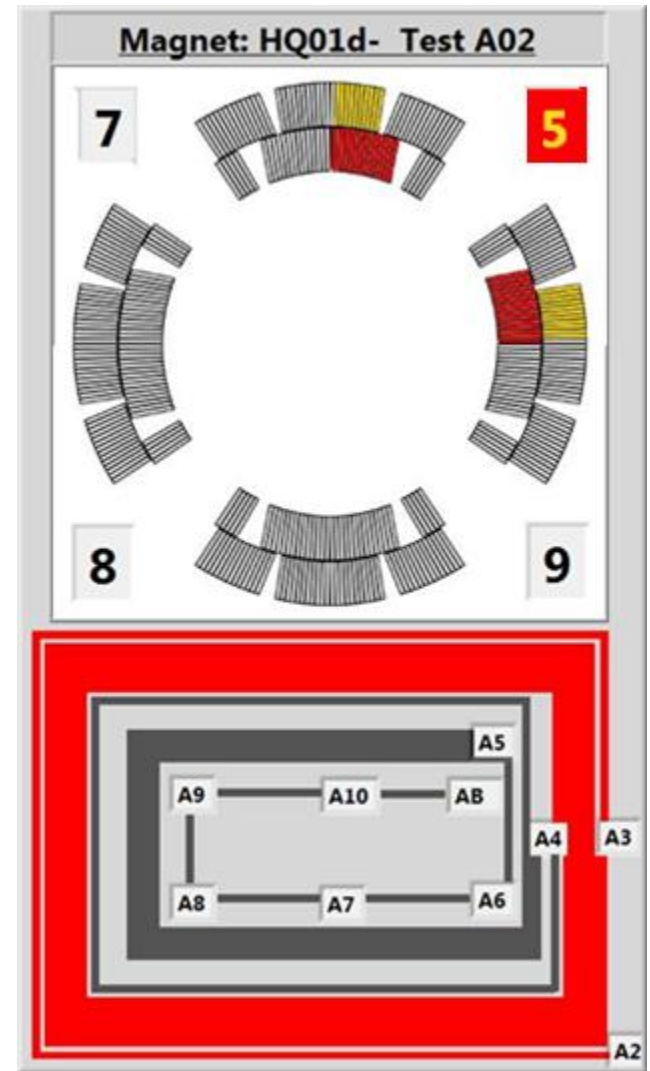
Fast ramp, mid-plane quench (A02)

100 A/s



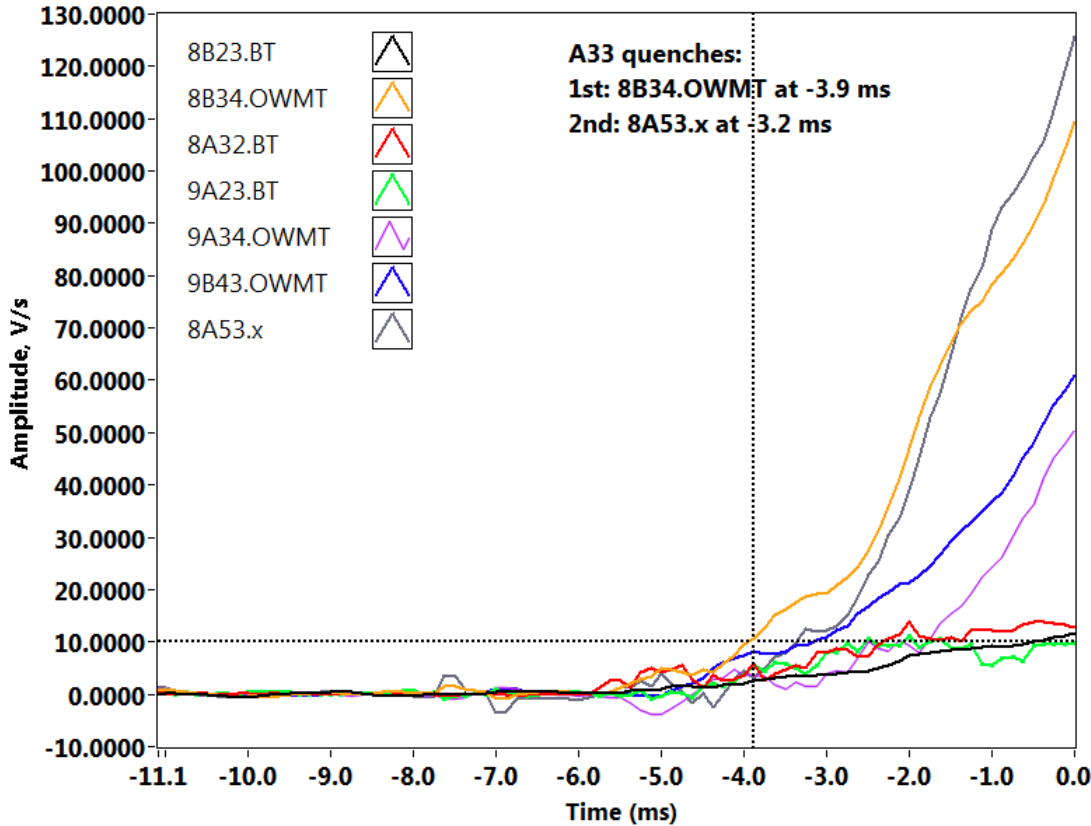
$I = 8068 \text{ A}$

$MIITS = 5.12$



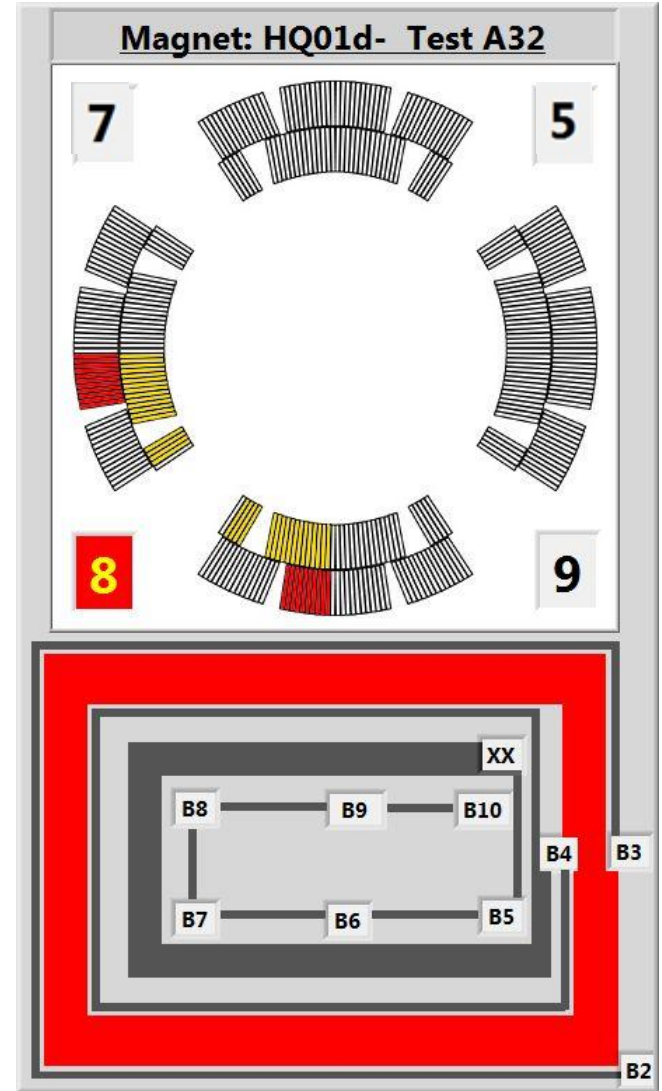
Fast ramp, mid-plane quench (A33)

50 A/s to 5 kA, then 35 A/s

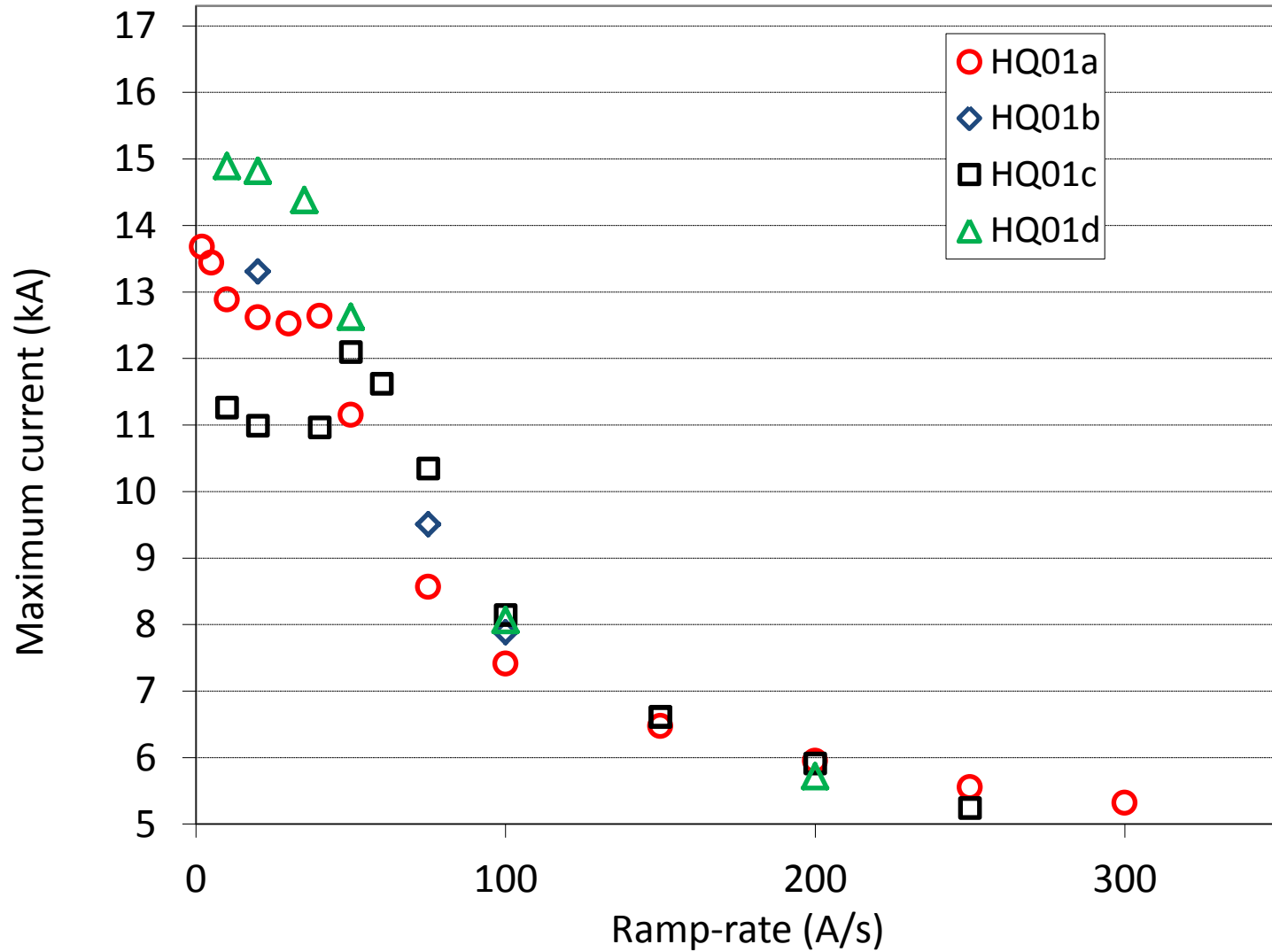


I = 14318 A

MIITS = 9.63



Ramp-rates quenches



- HQ01d reached 86% of Iss showing a “typical” quench pattern with instabilities originated in the pole region and most likely caused by slippages.
- The majority of the training quenches in HQ01d occurred in the pole region of coil 8. Out of those, 9 occurred in layer A, straight section (near VT7) and the rest (6) was distributed between pole and straight sections of both layers.
- The remaining training quenches occurred mostly in the mid-plane of coil 7 (5) , at the side facing coil 8.
- Fast ramp-rate quenches (200, 50, 35 A/s) occurred in the multi-turn of coil 8, one (50 A/s) in coil 5.