U.S. MAGNET DEVELOPMENT PROGRAM

CT hybrid dipole study and comparison with the CC

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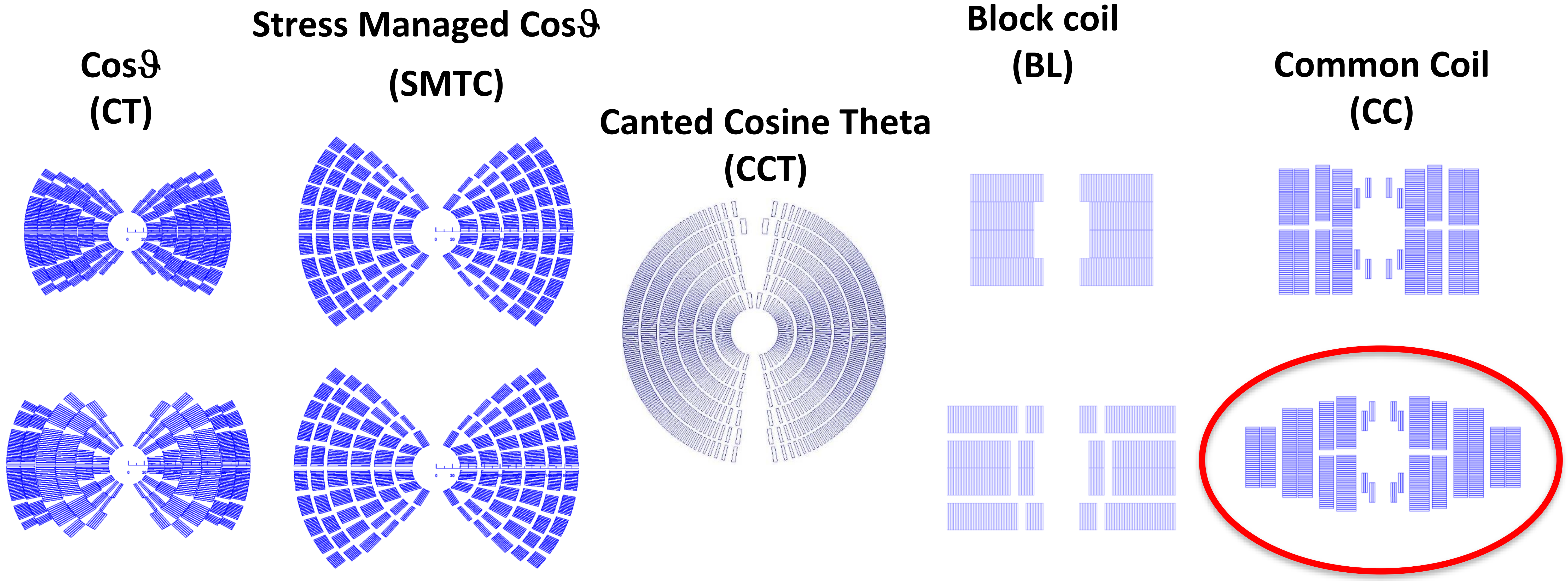
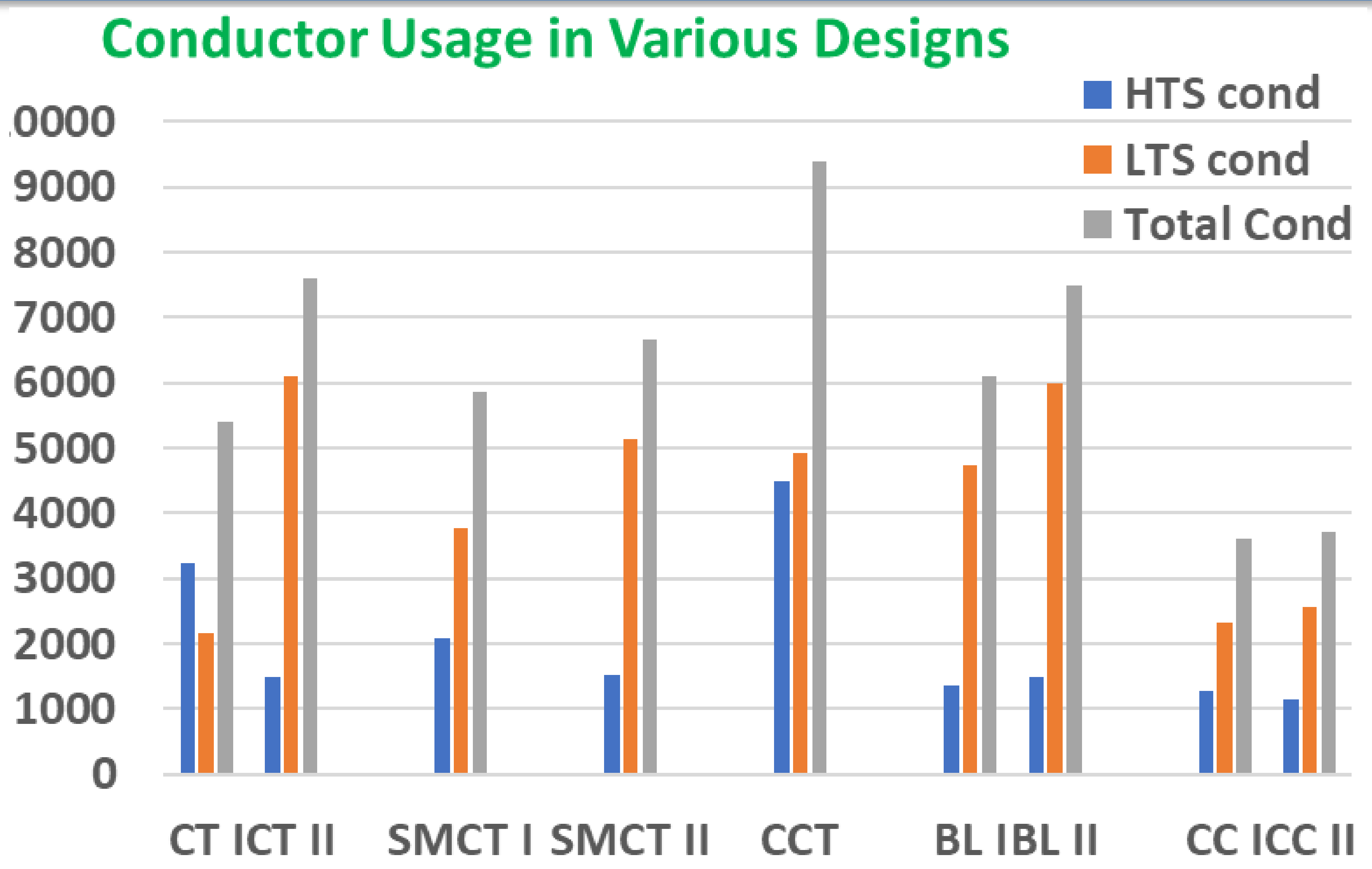
US-MDP 20 T group meeting

09/27/2022

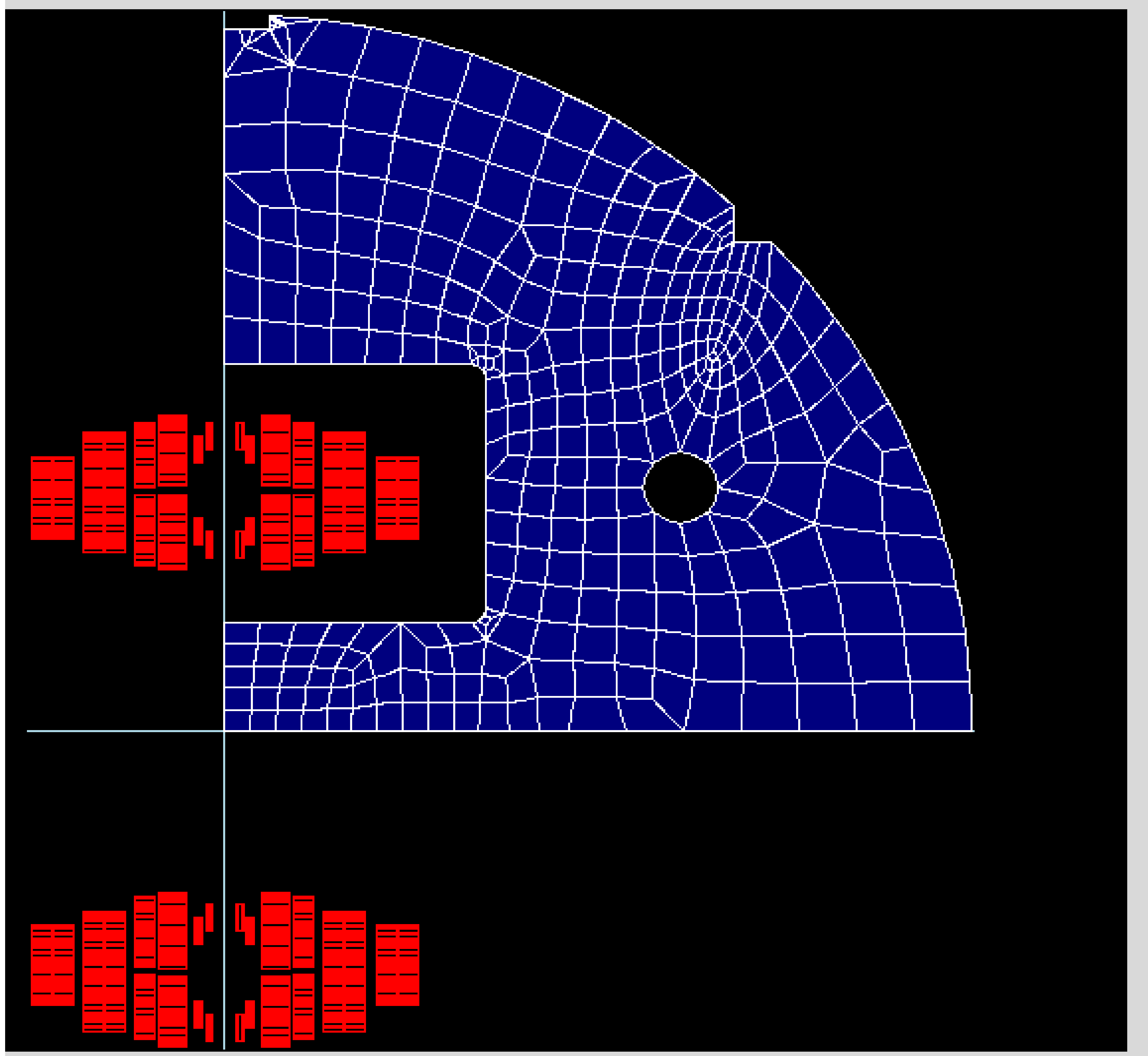
Initial Observation from the Comparative Study of Various Designs – R. Gupta

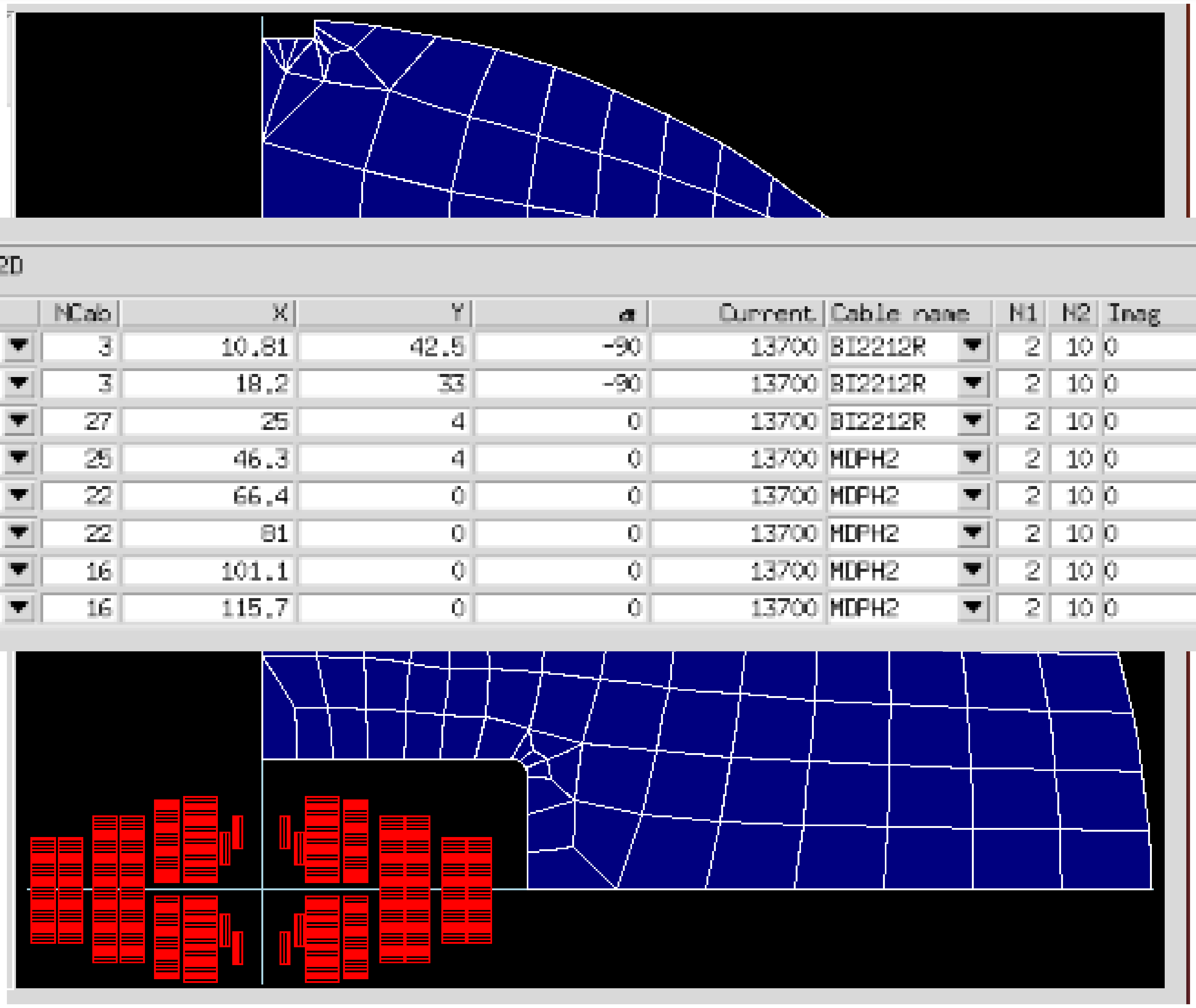




- <u>Comparative studies of 20 T designs (as presented at MT) revealed that the common coil design uses significantly less conductor than the other designs</u>. Small differences in relative margin doesn't explain that.
- This finding is opposite to that expected from the conventional wisdom. Why? Back to the design board…
- Explanation comes from the basic design principles. As the design field gets higher, relative ratio between the bore area and the coil area changes significantly. That changes the optimization and the outcome.
- The difference is likely to grow for field quality magnets and particularly on the use of the expensive HTS

CC coil design transformation



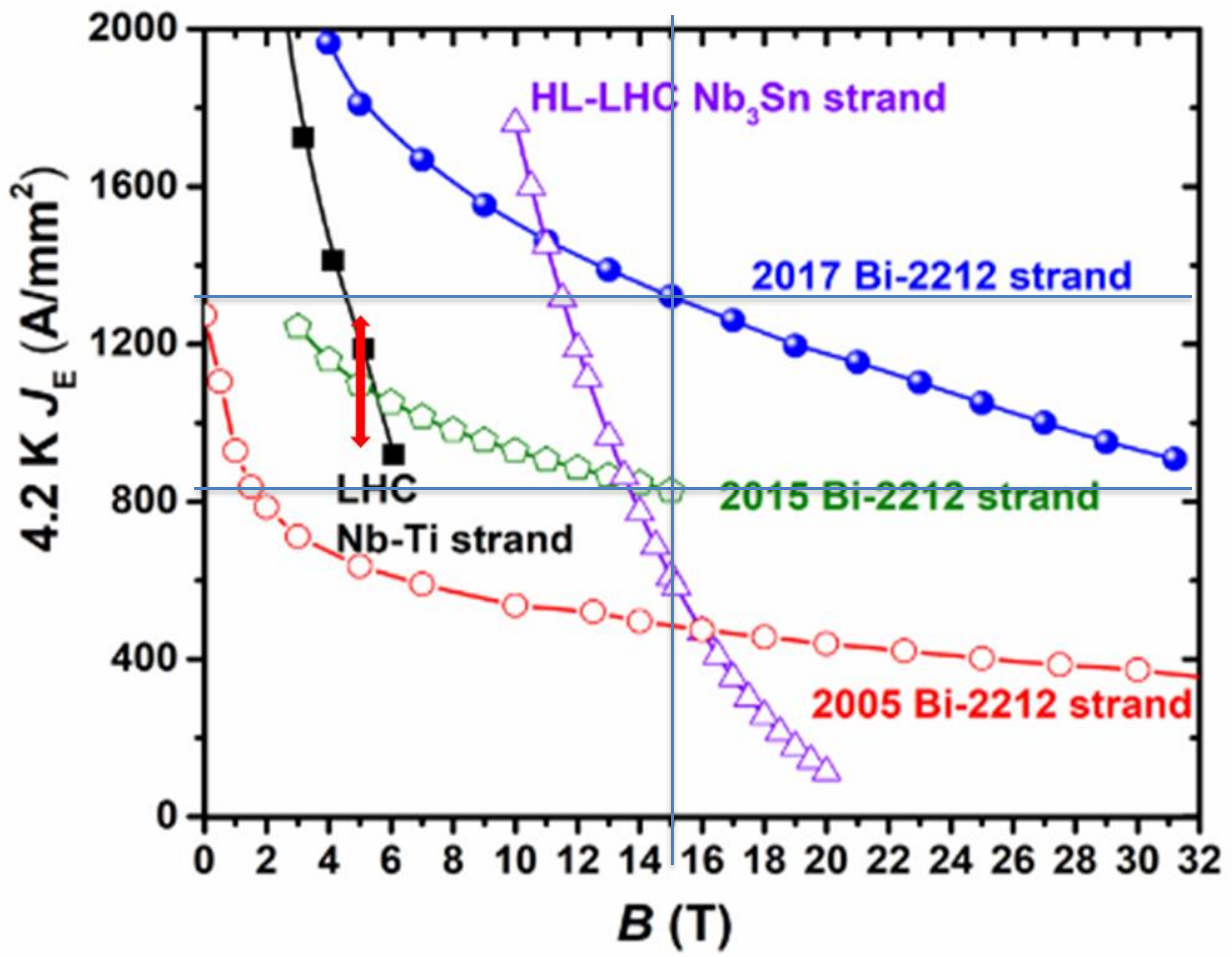


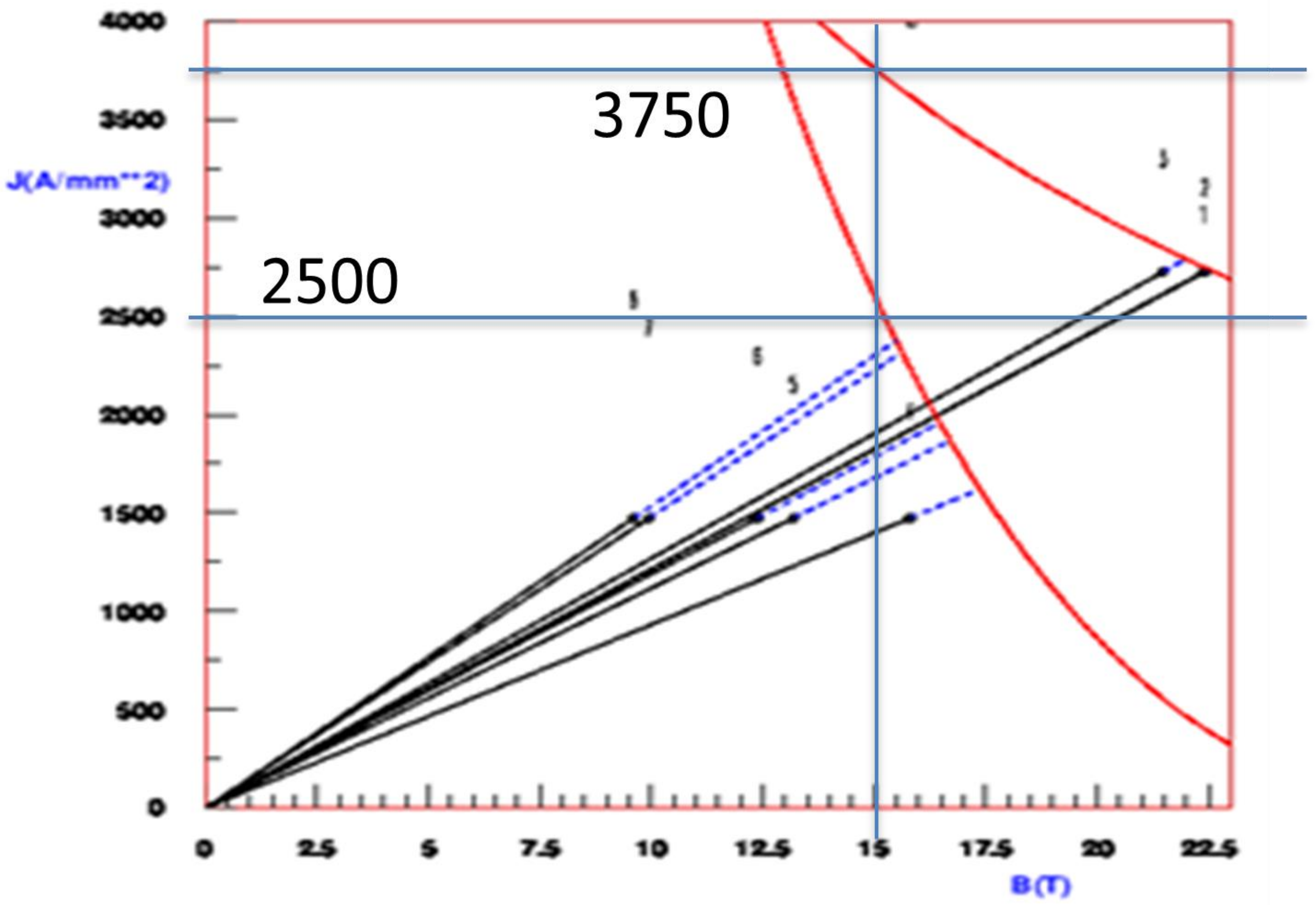
Block Data 2D

No	Type	NCab	X	Y	α	Current	Cable name	N1	N2	Imag	Turn
1	Rect	3	10.81	42.5	-90	13700	BI2212R	2	10	0	0
2	Rect	3	18.2	33	-90	13700	BI2212R	2	10	0	0
3	Rect	27	25	4	0	13700	BI2212R	2	10	0	0
4	Rect	25	46.3	4	0	13700	MDPH2	2	10	0	0
5	Rect	22	66.4	0	0	13700	MDPH2	2	10	0	0
6	Rect	22	81	0	0	13700	MDPH2	2	10	0	0
7	Rect	16	101.1	0	0	13700	MDPH2	2	10	0	0
8	Rect	16	115.7	0	0	13700	MDPH2	2	10	0	0

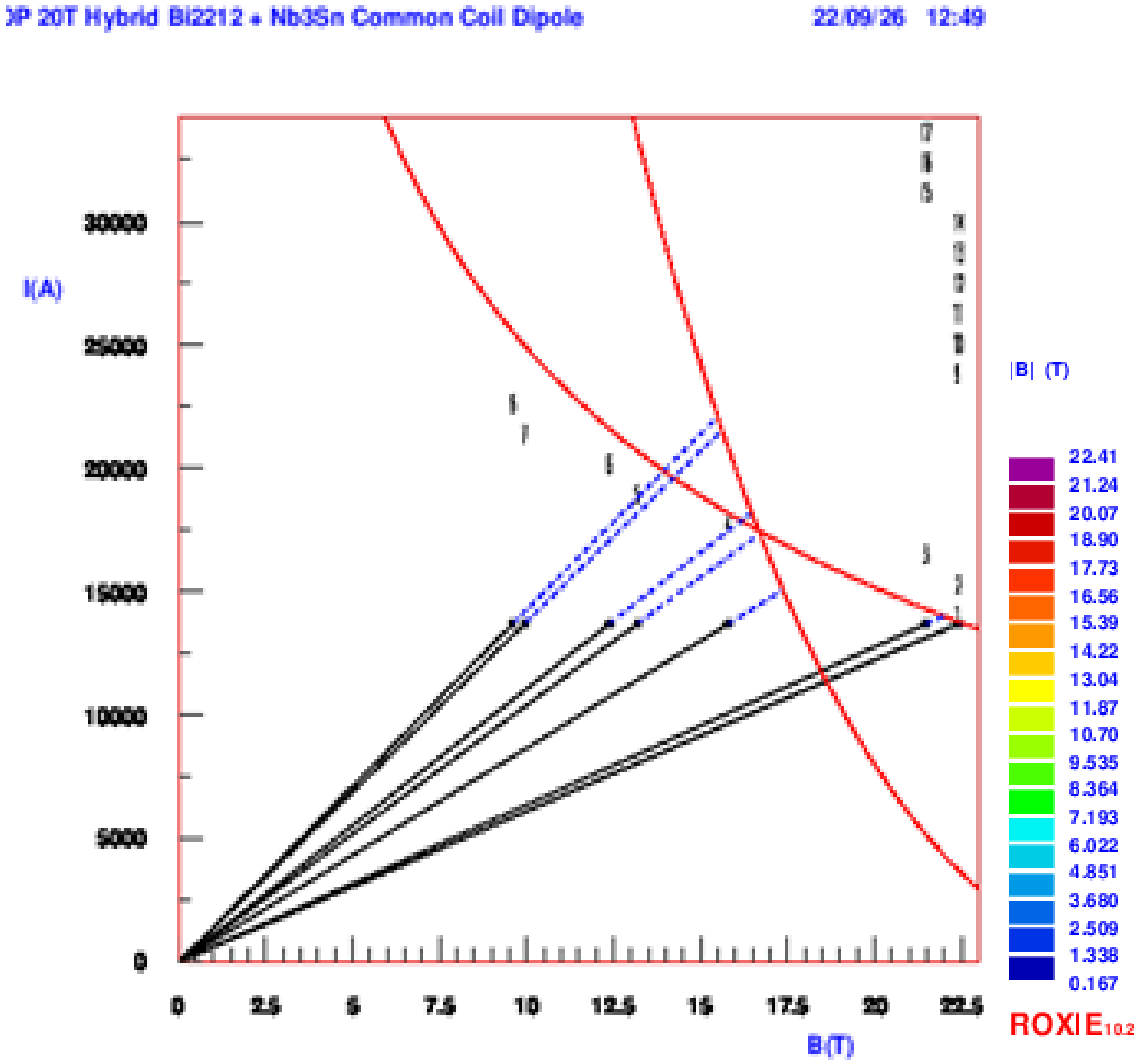
- Asymmetric CC cross-section turned to symmetrical and placed in the iron yoke center
- Yoke OD were not changed

Conductor parameters

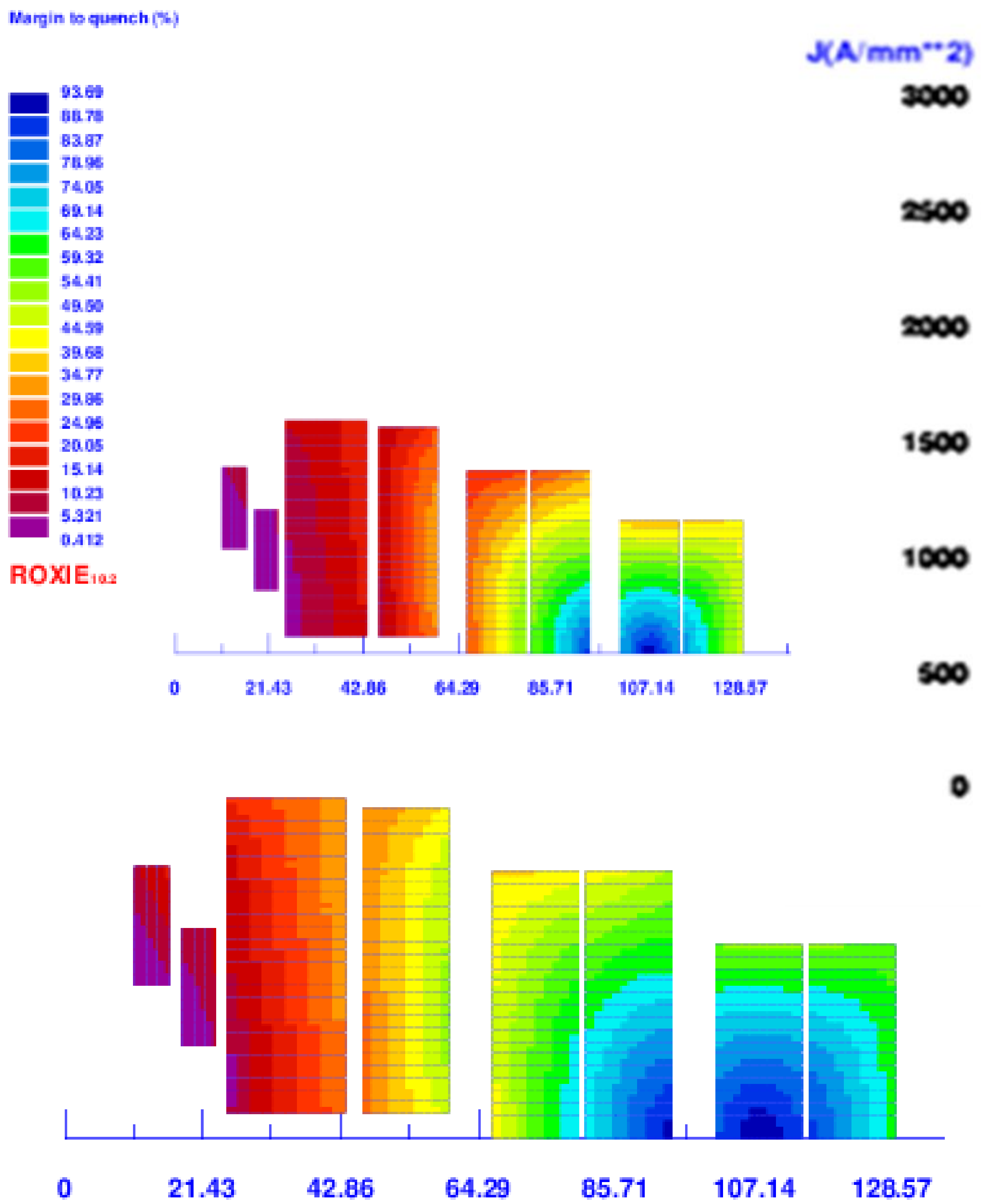


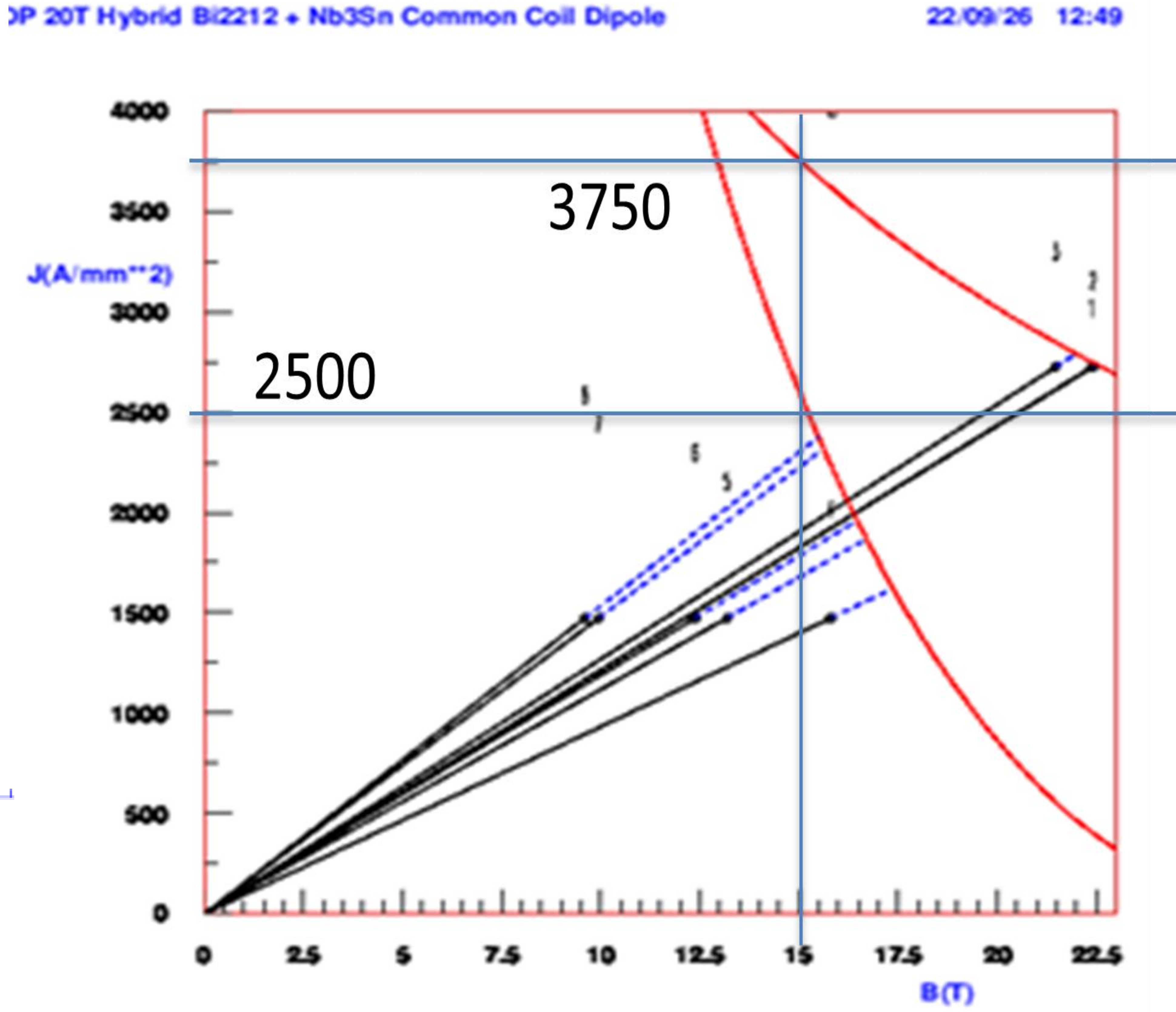


CC coil design parameters



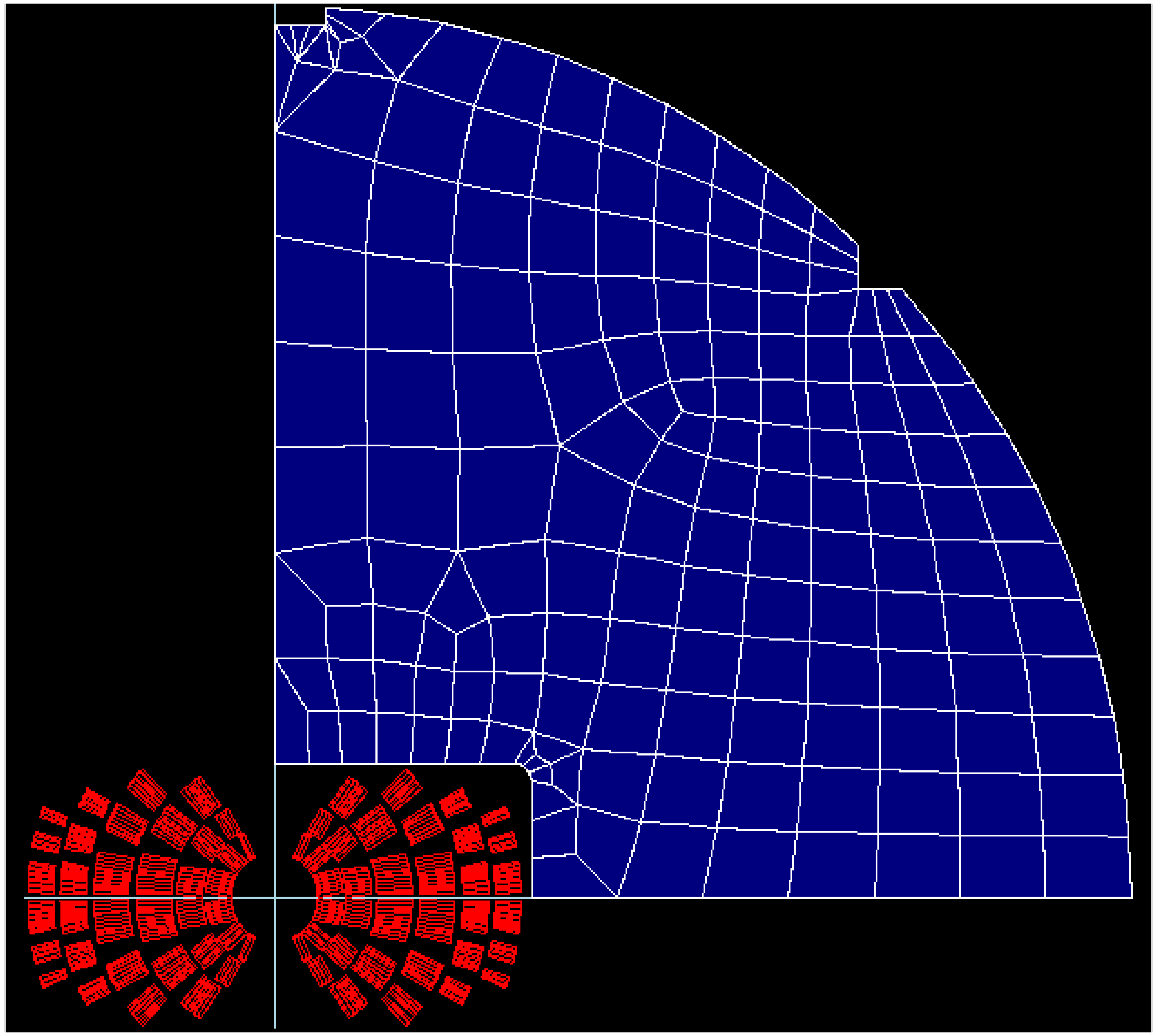
B_{max}=22.41 T
Margin to quench 0.112%





- a
- b

CT coil design



Block Data 2D

No	Type	NCab	R	φ	α	Current	Cable name	N1	N2	Imag	Turn
1	Cos	6	25	0.229	10	16000	BI1S15	2	15	0	0
2	Cos	4	25	29.5021	40	16000	BI1S15	2	15	0	0
3	Cos	3	25	53.7611	65	16000	BI1S15	2	15	0	0
4	Cos	7	41.7	0.15	7	16000	BI1S15	2	15	0	0
5	Cos	6	41.7	28.1226	41	16000	BI1S15	2	15	0	0
6	Cos	4	41.7	50.6226	58	16000	BI1S15	2	15	0	0
7	Cos	10	60	1.15	0	16000	15TFNAL1	2	20	0	0
8	Cos	8	60	25.77	30.77	16000	15TFNAL1	2	20	0	0
9	Cos	6	60	46.53	50.53	16000	15TFNAL1	2	20	0	0
10	Cos	10	85	1.06	1.56	16000	15TFNAL1	2	20	0	0
11	Cos	7	85	20	25	16000	15TFNAL1	2	20	0	0
12	Cos	6	85	34.5	40	16000	15TFNAL1	2	20	0	0
13	Cos	11	110	1	1.26	16000	FNAL40_NC	2	15	0	0
14	Cos	9	110	13	10.59	16000	FNAL40_NC	2	15	0	0
15	Cos	7	110	24	24	16000	FNAL40_NC	2	15	0	0
16	Cos	11	129	1	1.26	16000	FNAL40_NC	2	15	0	0
17	Cos	6	129	11	13	16000	FNAL40_NC	2	15	0	0
18	Cos	4	129	18	20	16000	FNAL40_NC	2	15	0	0

Running ROXIE on file Bi2212-Nb3Sn_6LDv7-1_RealYoke600.data...

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MAIN FIELD (T) .......................................     -21.920183
MAGNET STRENGTH (T/(m^(n-1)) .........................       -21.9202

NORMAL RELATIVE MULTIPOLES (1.D-4):
b 1:  10000.00000  b 2:      0.00000  b 3:    -0.62287
b 4:      0.00000  b 5:     -0.59559  b 6:     0.00000
b 7:      0.15419  b 8:      0.00000  b 9:    -0.03283
b10:      0.00000  b11:      0.00429  b12:     0.00000
b13:     -0.00074  b14:      0.00000  b15:    -0.00012
b16:      0.00000  b17:      0.00002  b18:     0.00000
b19:      0.00000  b20:      0.00000  b
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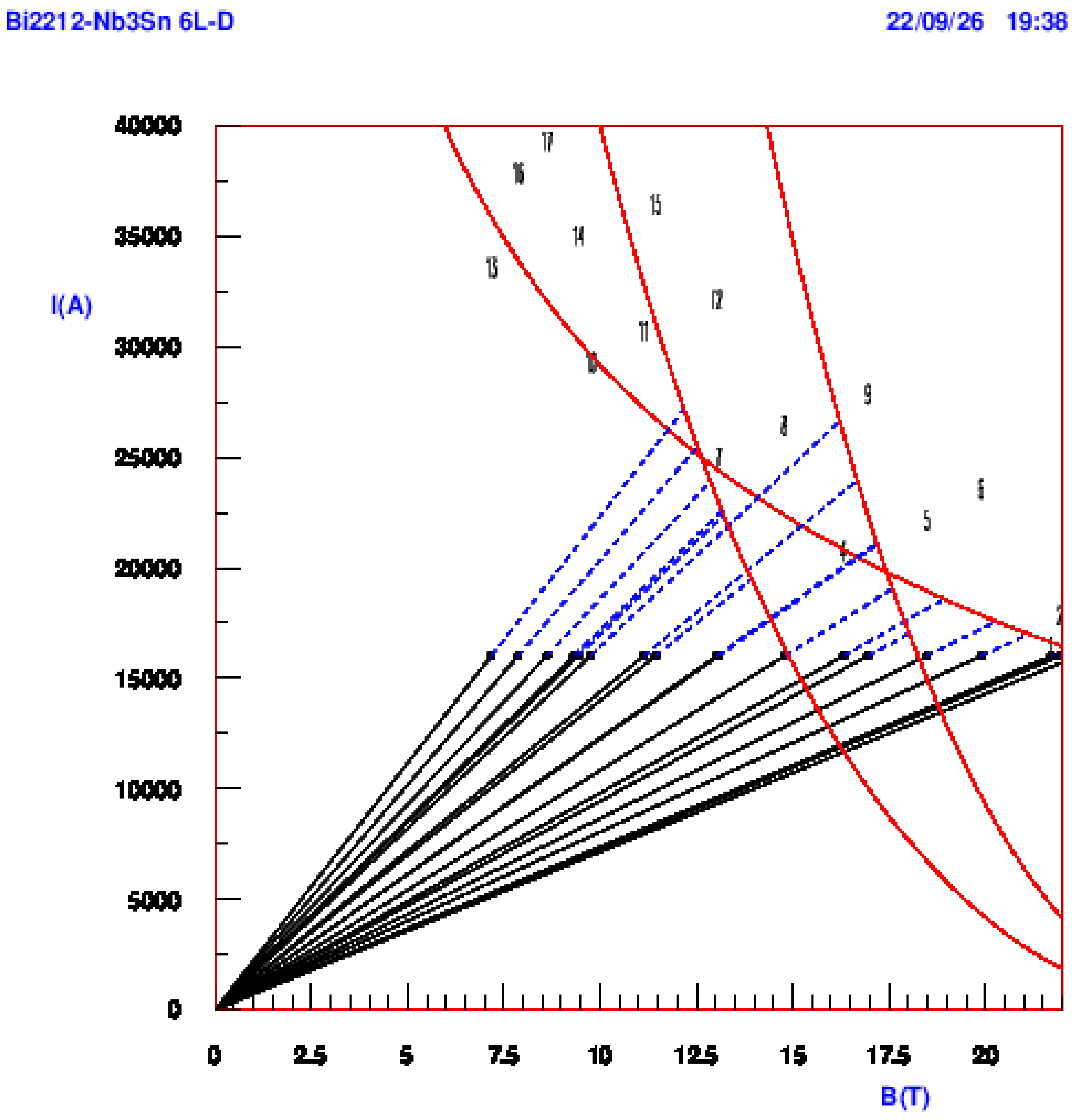
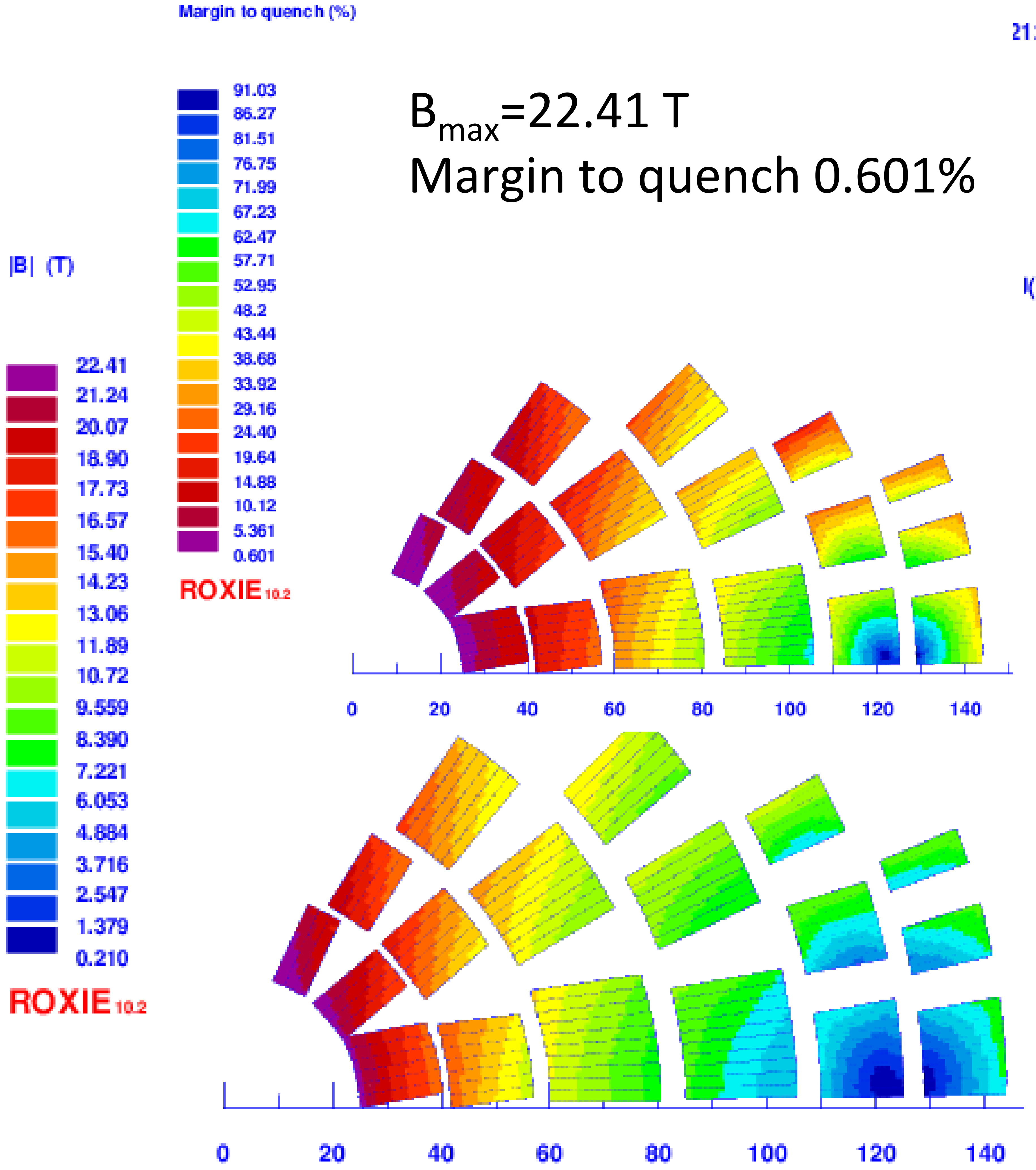
- 6L graded CT coil placed in the same iron yoke
- SM elements added

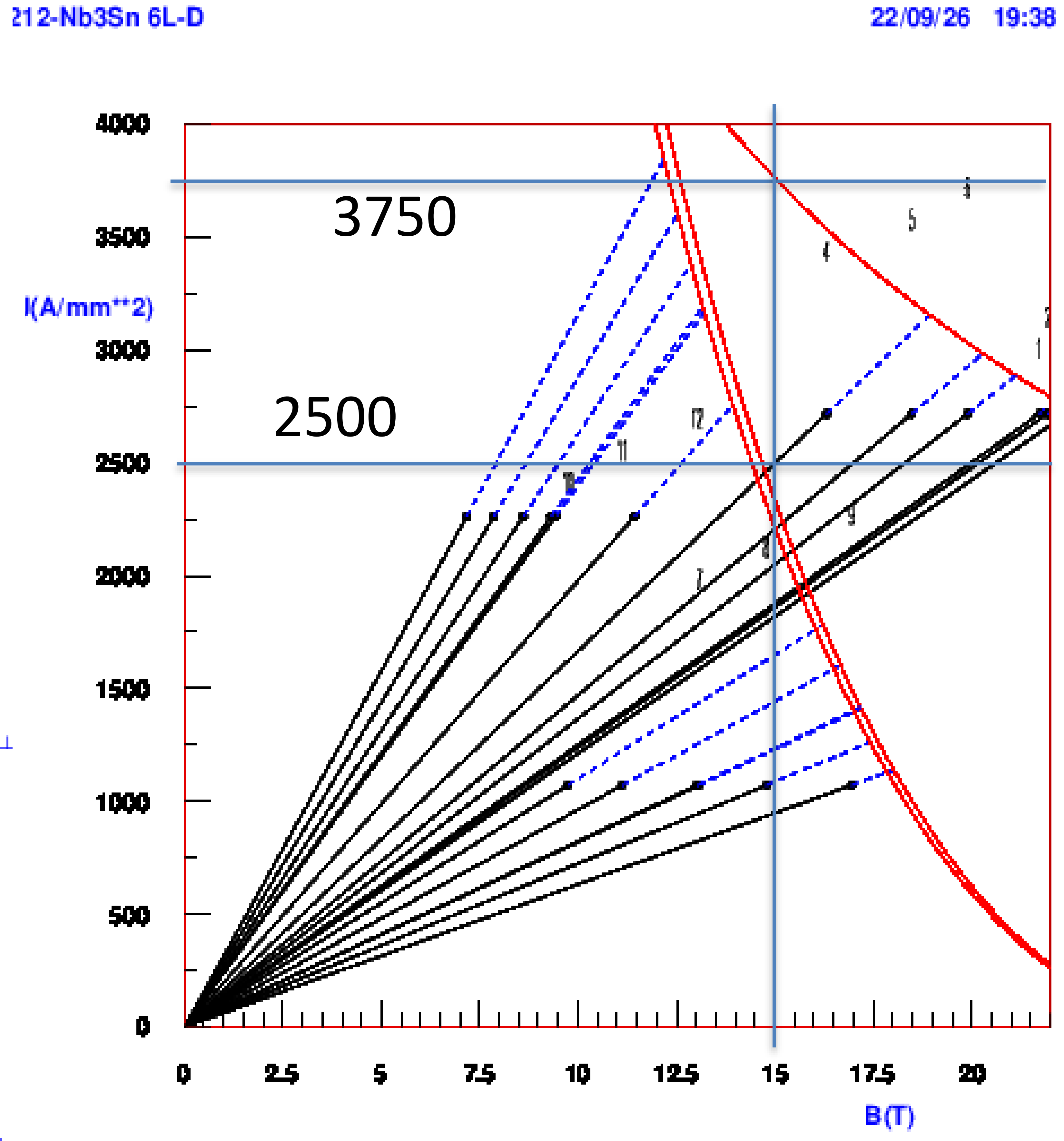
CT coil design





B_{max}=22.41 T

Margin to quench 0.601%



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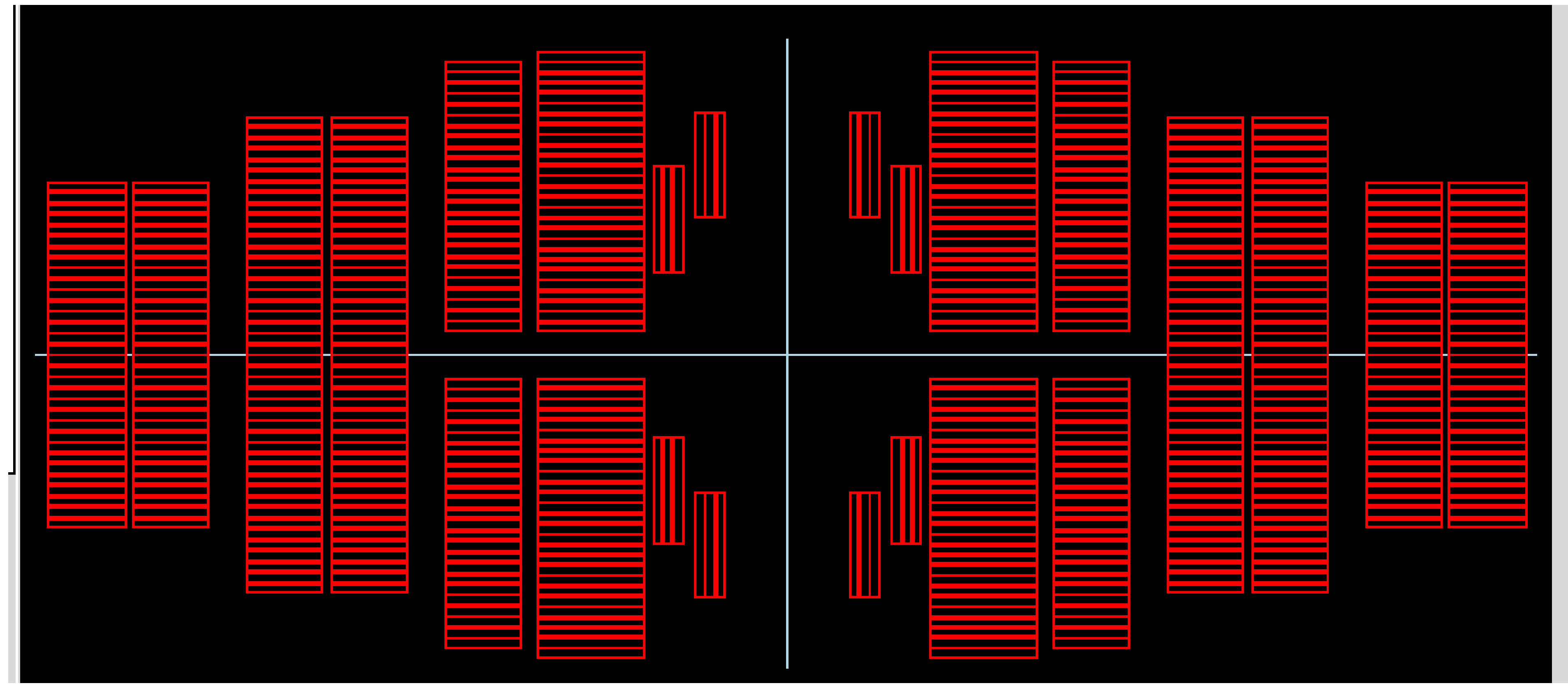
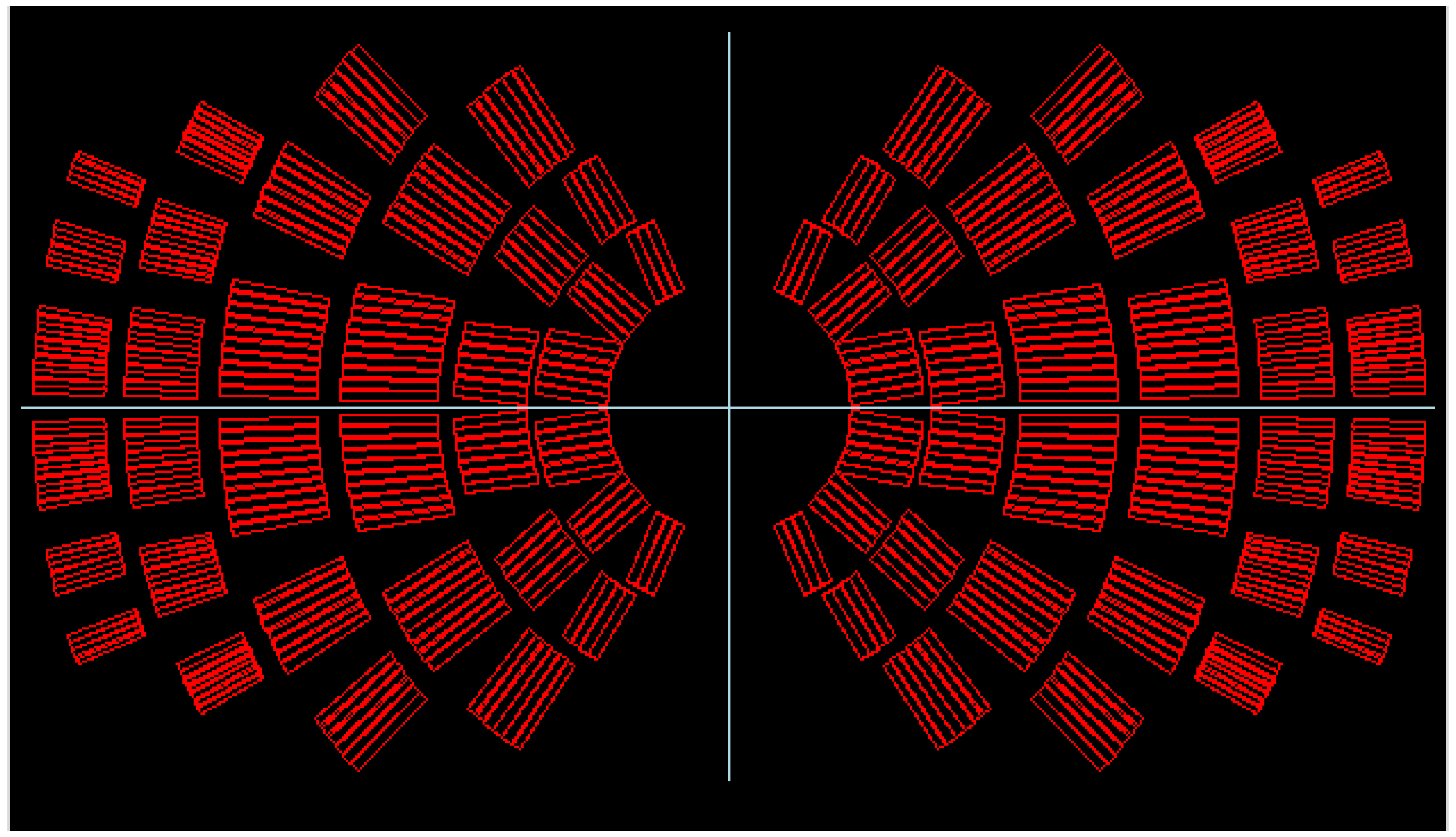
CC and CT coil cable cross-section area

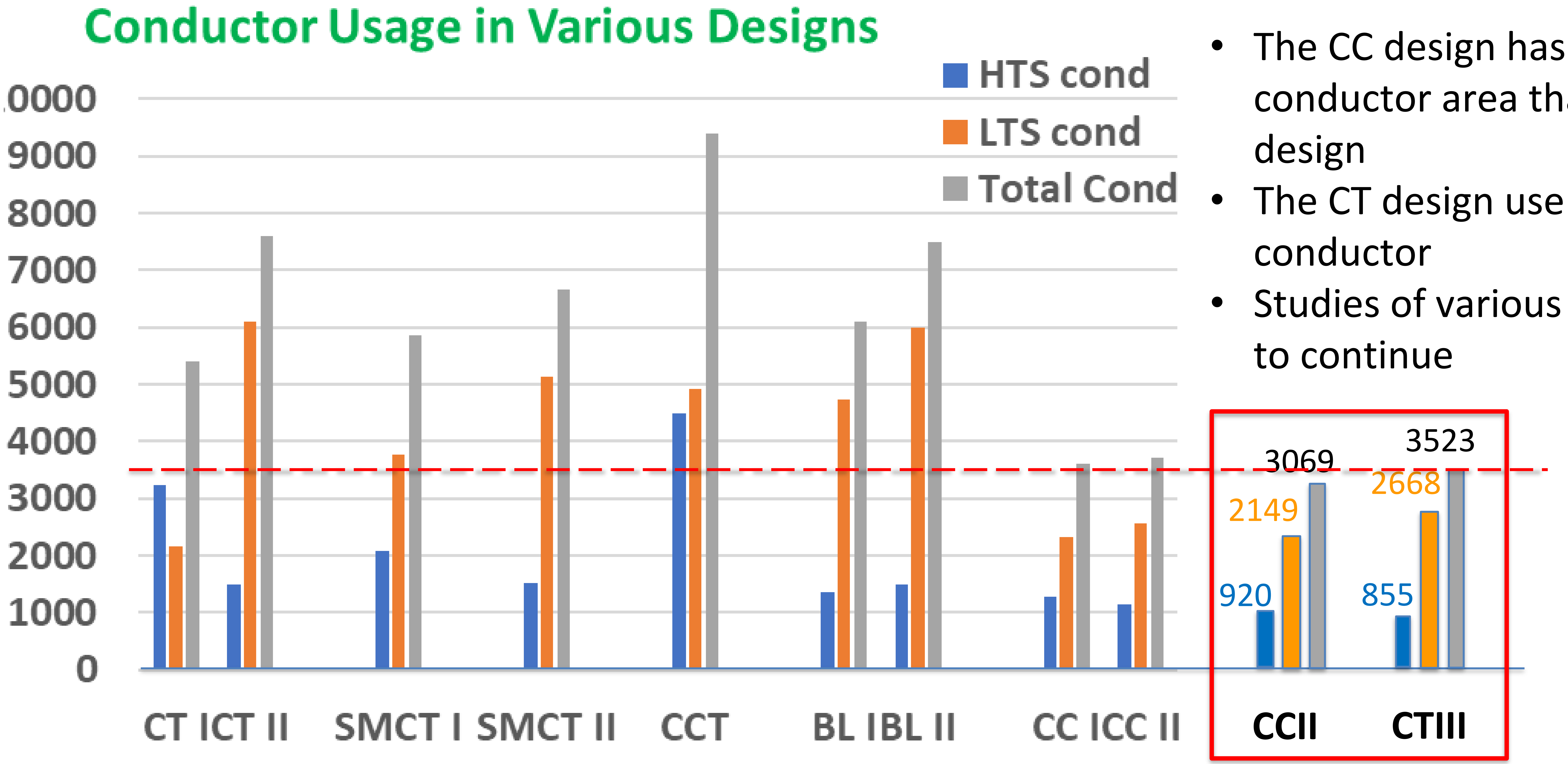


		W, mm	h, mm	Sc, mm2	Stot, mm2
n	BI2212R	18.4	1.52	27.89	**920**
6					
27					
33					
	MDPH2	13.3	1.6	21.28	**2149**
25					
22					
22					
16					
16					
101					
				Total S	**3069**



		W, mm	h, mm	Sc, mm2	Stot, mm2
n	BI1S15	15	1.9	28.5	**855**
13					
17					
30					
	15TFNAL1	20.2	1.83	36.966	**1737**
24					
23					
47					
	FNAL_40_NC	14.85	1.31	19.40	**931**
27					
21					
48					
				Total S	**3523**

Summary and conclusion



- The CC design has smaller total conductor area than the CT design
- The CT design use less HTS conductor
- Studies of various designs need to continue