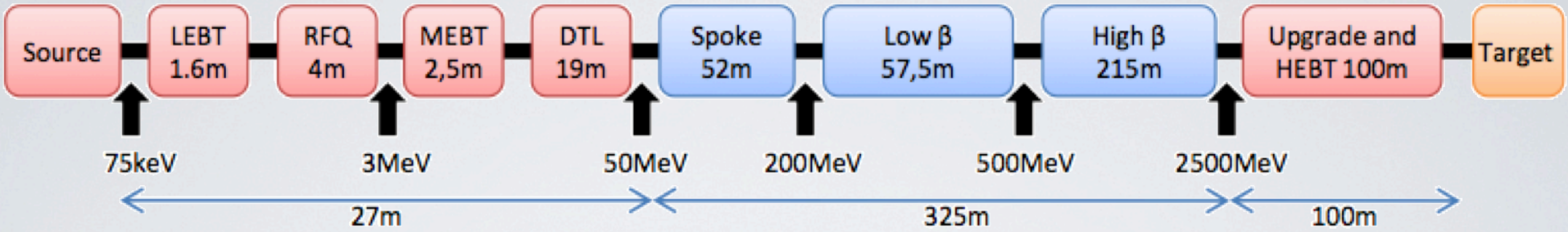
ALL THE ESS CRYOS

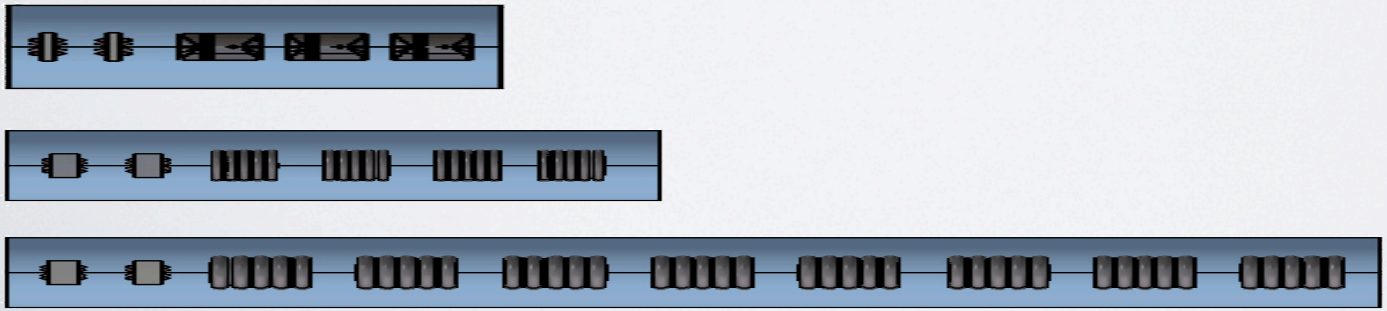
M. Eshraqi

2 July 2010, 4th SPL collaboration meeting jointly with ESS

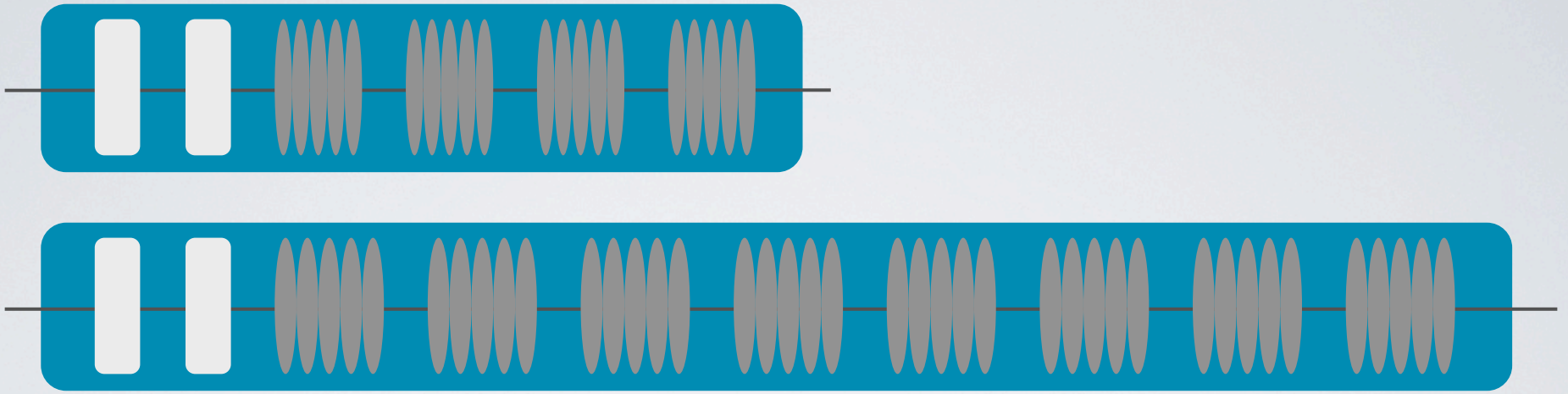
ESS LINAC LAYOUT



	Length (m)	Input Energy (MeV)	Frequency (MHz)	Geometric β	# of Sections	Temp (K)
RFQ	4	75×10^{-3}	352.2	--	1	≈ 300
DTL	19	3	352.2	--	3	≈ 300
Spoke	52	50	352.2	0.45	14	≈ 2
Low Beta	57.5	200	704.4	0.63	10	≈ 2
High Beta	215	500	704.4	0.75	19	≈ 2
HEBT	100	2500	--	--	--	--



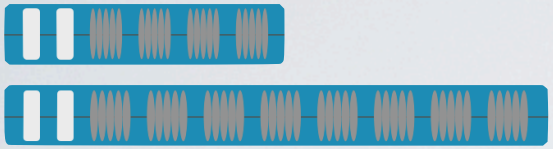
NOMINAL CRYO



C.CQ.DCR.2	Beta_Geo	No. of Cryos	Length	No. of Cavities	No of Quads
Spokes	0.54	16	65.1	48	32
Low Beta	0.67	9	53.3	36	18
High Beta	0.84	14	169.4	112	28
Total	--	16 + 23	65.1 + 222.7	48 + 148	32 + 46

High Beta 75	0.84	21	254.1	168	42

NOMINAL CRYO. HP

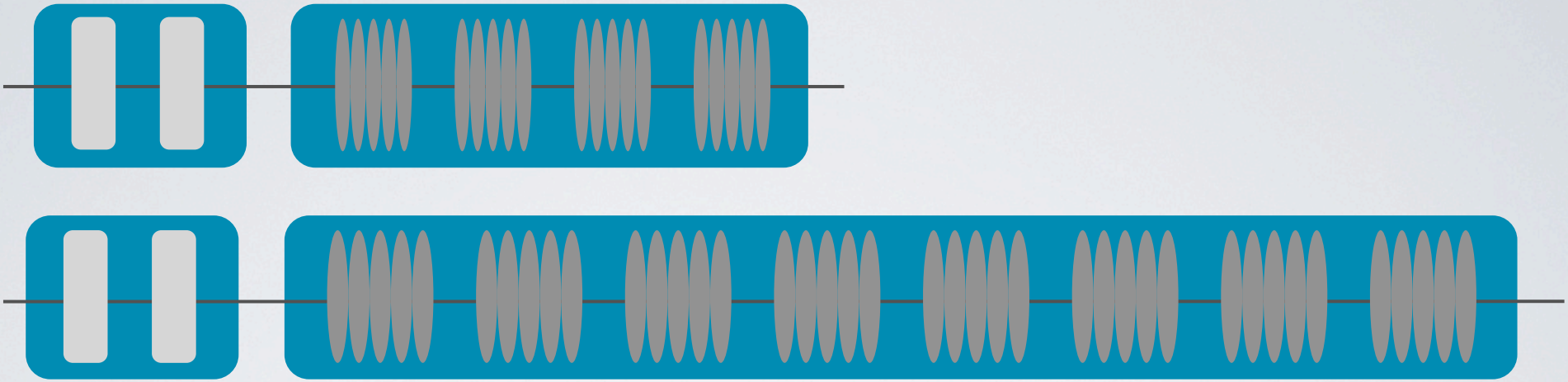


Cryo to Quad	mm	250	Cavity to Cryo	mm	250
Quad to Quad	mm	400	Cryo to Cryo	mm	100
Quad to Cavity	mm	400	Quad Length (Spk/Ellip)	mm	250 / 400
Cavity to Cavity	mm	300 / 400	Quad Aper. (Spk/Ellip)	mm	20 / 50

C.CQ.DCR.2	Beta_Geo	No. of Cryos	Length	No. of Cavities	No of Quads
Spokes	0.51	14	55.3	42	28
Low Beta	0.63	9	51.8	36	18
High Beta	0.75	21	238.0	168	42
Total	--	14 + 30	55.3 + 289.8	42 + 204	28 + 60

High Beta 50	0.75	19	215.3	152	38

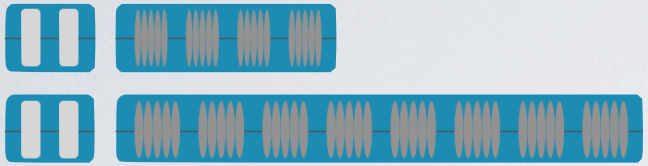
COLD SEP. QUADS



C.SQ.DCR.2	Beta_Geo	No of Cryos	Length	No of Cavities	No of Quads
Spokes	0.53	18	72.5	54	36
Low Beta	0.66	7	49.8	28	14
High Beta	0.84	15	195.7	120	30
Total	--	18 + 22	72.5 + 245.5	54 + 148	36 + 44

High Beta 75	0.84	21	274.1	168	42

COLD SEP. QUADS HP

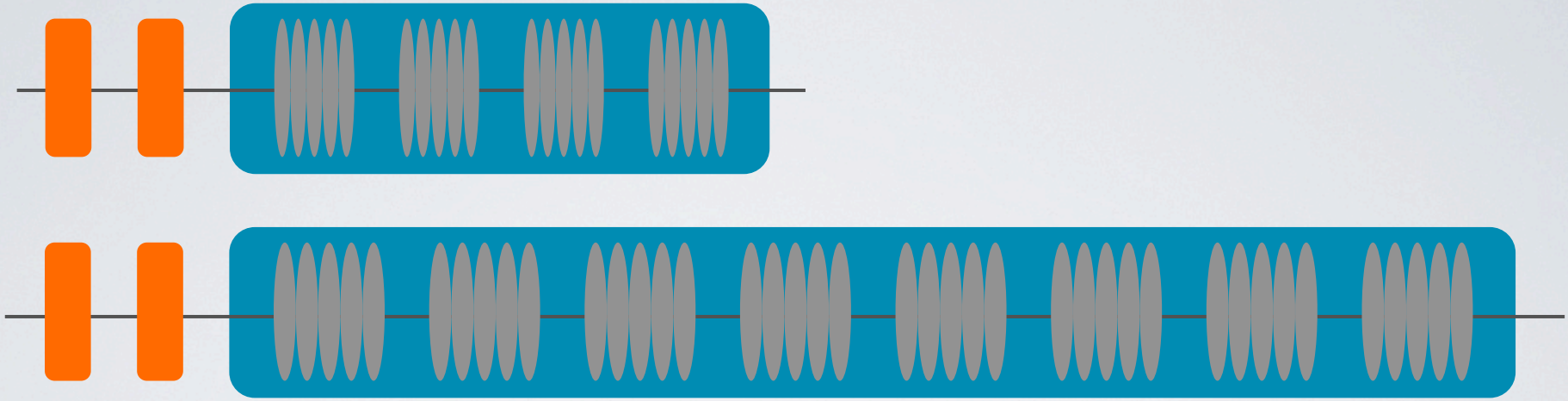


Cryo to Quad	mm	300	Cryo to Cavity	mm	400
Quad to Quad	mm	400	Cavity to Cavity	mm	400
Quad to Cryo	mm	300	Cavity to Cryo	mm	400
Q.Cryo to C.Cryo	mm	200	C.Cryo to Q.Cryo	mm	300

C.SQ.DCR.2	Beta_Geo	No of Cryos	Length	No of Cavities	No of Quads
Spokes	0.53	16	64.5	48	32
Low Beta	0.66	8	56.9	32	16
High Beta	0.75	21	258.0	168	42
Total	--	16 + 29	64.5 + 314.9	48 + 200	32 + 58

High Beta 50	0.75	19	233.4	152	38

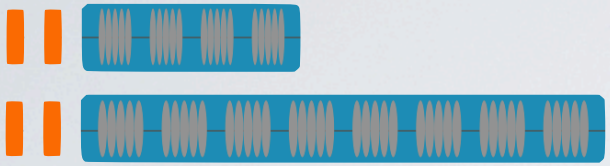
WARM QUADS



W.SQ.DCR.2	Beta_Geo	No of Cryos	Length	No of Cavities	No of Quads
Spokes	0.54	16	65.1	48	32
Low Beta	0.68	9	58.5	36	18
High Beta	0.85	14	174.1	112	28
Total	--	16 + 23	65.1 + 232.5	48 + 148	32 + 46

High Beta 75	0.85	21	261.1	168	42

WARM QUADS HP

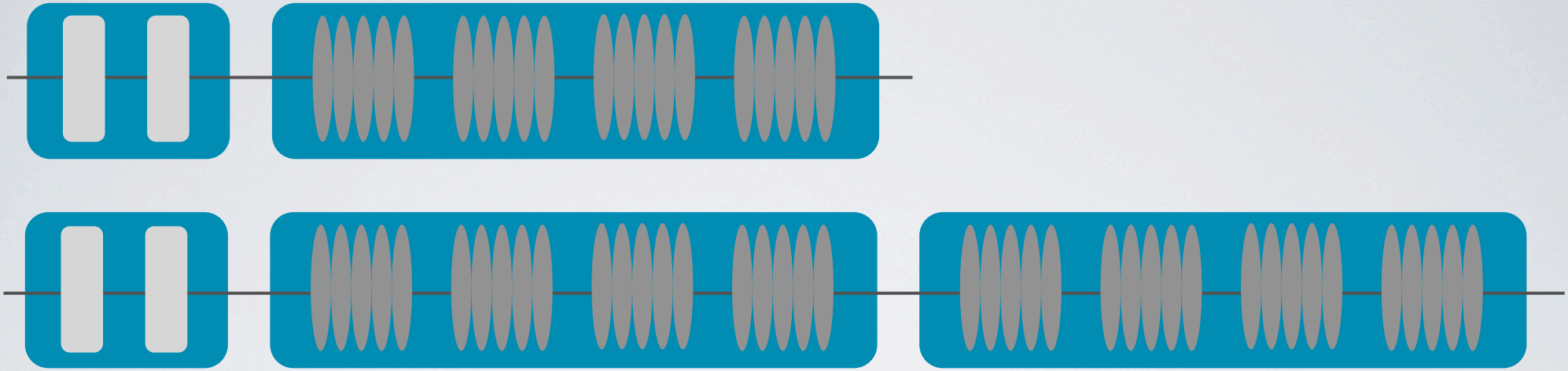


Cryo to Quad	mm	200	Cavity to Cryo	mm	400
Quad to Quad	mm	400			
Quad to Cryo	mm	200			
Cryo to Cavity	mm	400			

W.SQ.DCR.2	Beta_Geo	No of Cryos	Length	No of Cavities	No of Quads
Spokes	0.53	17	68.5	51	34
Low Beta	0.64	7	44.3	28	14
High Beta	0.75	21	243.3	168	42
Total	--	17 + 28	68.5 + 287.6	51 + 196	34 + 56

High Beta 50	0.75	19	220.1	152	38

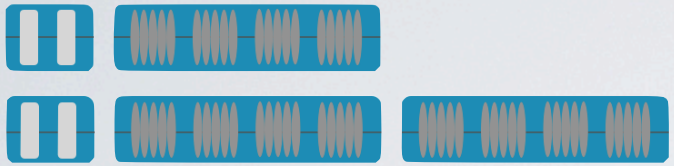
1 BETA COLD QUAD



C.SQ.UCR.1	Beta_Geo	No of Cryos	Length	No of Cavities	No of Quads
Spokes	0.53	19	76.6	57	38
Low Beta	0.82	9	70.1	36	18
High Beta	0.82	28 / 2	187.3	112	28
Total	--	19 + 37	76.6 + 257.4	57 + 148	38 + 46

High Beta 75	0.82	40 / 2	267.6	160	40

1 BETA COLD QUAD HP

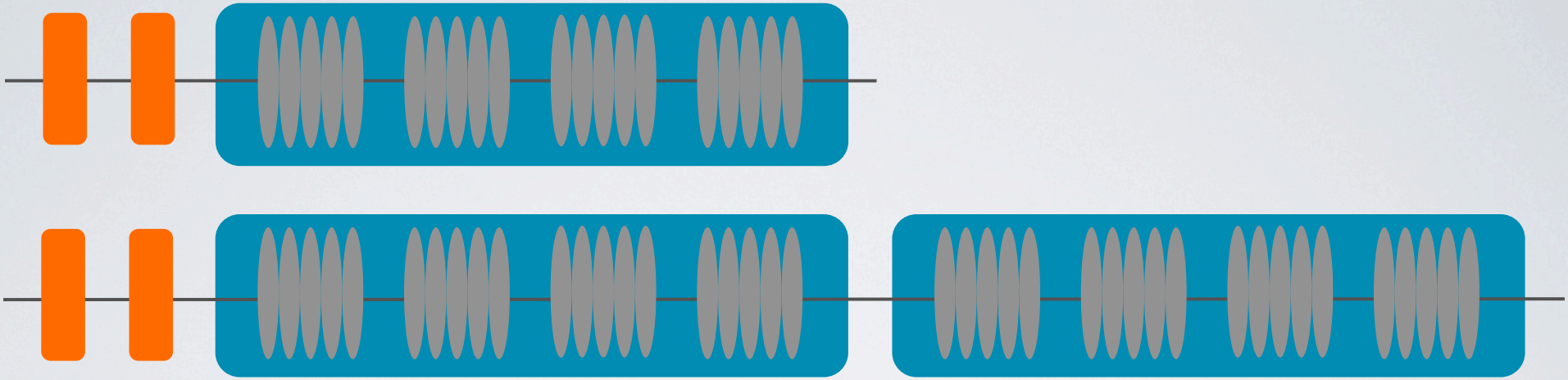


Cryo to Quad	mm	300	Cryo to Cavity	mm	400
Quad to Quad	mm	400	Cavity to Cavity	mm	400
Quad to Cryo	mm	300	Cavity to Cryo	mm	400
Q.Cryo to C.Cryo	mm	200	C.Cryo to C/Q.Cryo	mm	100/300

C.SQ.UCR.1	Beta_Geo	No of Cryos	Length	No of Cavities	No of Quads
Spokes	0.54	19	77.3	57	38
Low Beta	0.76	7	52.7	28	14
High Beta	0.76	40 / 2	257.4	160	40
Total	--	19 + 47	77.3 + 310.1	57 + 188	38 + 54

High Beta 50	0.76	38 / 2	244.5	152	38

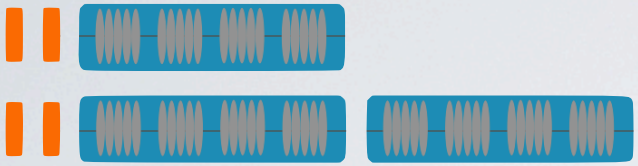
1 BETA WARM QUAD



W.SQ.UCR.1	Beta_Geo	No of Cryos	Length	No of Cavities	No of Quads
Spokes	0.54	20	81.4	60	40
Low Beta	0.82	8	56.7	32	16
High Beta	0.82	28 / 2	177.5	112	28
Total	--	20 + 36	81.4 + 234.2	60 + 144	40 + 44

High Beta 75	0.82	40 / 2	253.6	160	40

1 BETA WARM QUAD HP

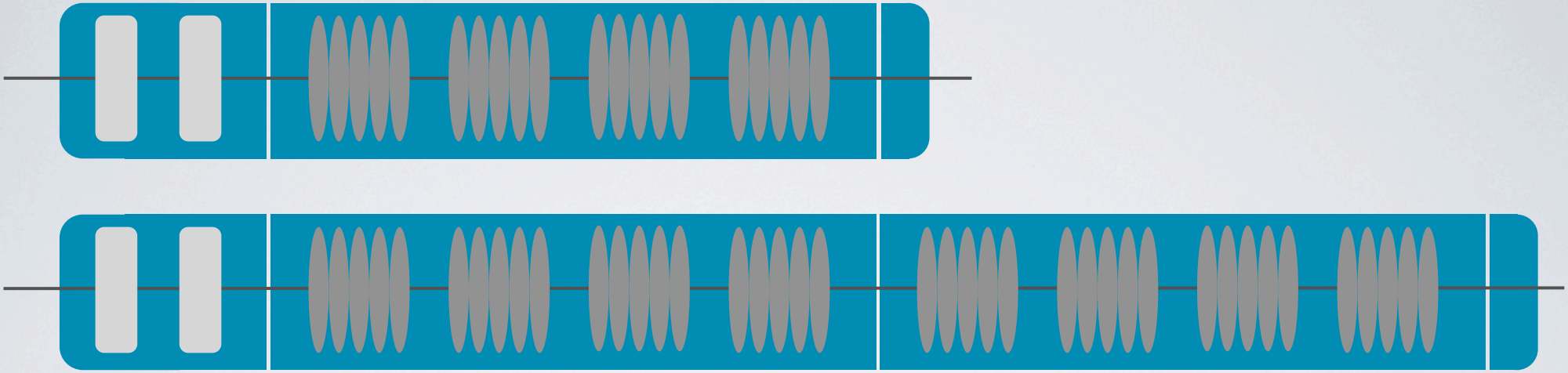


Cryo to Quad	mm	200	Cavity to Cavity	mm	400
Quad to Quad	mm	400	Cavity to Cryo	mm	400
Quad to Cryo	mm	200	Cryo to Cryo	mm	100
Cryo to Cavity	mm	400			

W.SQ.UCR.1	Beta_Geo	No of Cryos	Length	No of Cavities	No of Quads
Spokes	0.53	17	68.5	51	34
Low Beta	0.75	8	54.3	32	16
High Beta	0.75	40 / 2	241.7	160	40
Total	--	17 + 48	68.5 + 296.0	51 + 192	34 + 56

High Beta 50	0.75	38 / 2	229.6	152	38

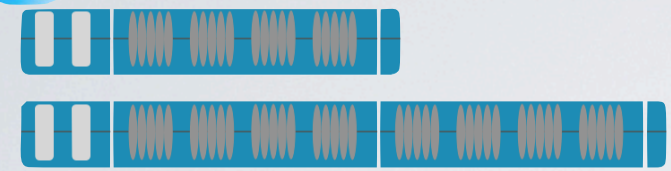
1 BETA COLD MODULAR



C.MQ.MCR.1	Beta_Geo	No of Cryos	Length	No of Cavities	No of Quads
Spokes	0.54	20	81.4	60	40
Low Beta	0.82	8	58.3	32	16
High Beta	0.82	28 / 2	176.1	112	28
Total	--	20 + 36	81.4 + 234.4	60 + 144	40 + 44

High Beta 75	0.82	40 / 2	251.6	160	40

1 BETA COLD MOD. HP



Cryo to Quad	mm	250	Cavity to Cavity	mm	400
Quad to Quad	mm	400	Cavity to Cryo	mm	300
Quad to Cryo	mm	150	End-Cap	mm	200
Cryo to Cavity	mm	300	Cryo to Cryo	mm	200

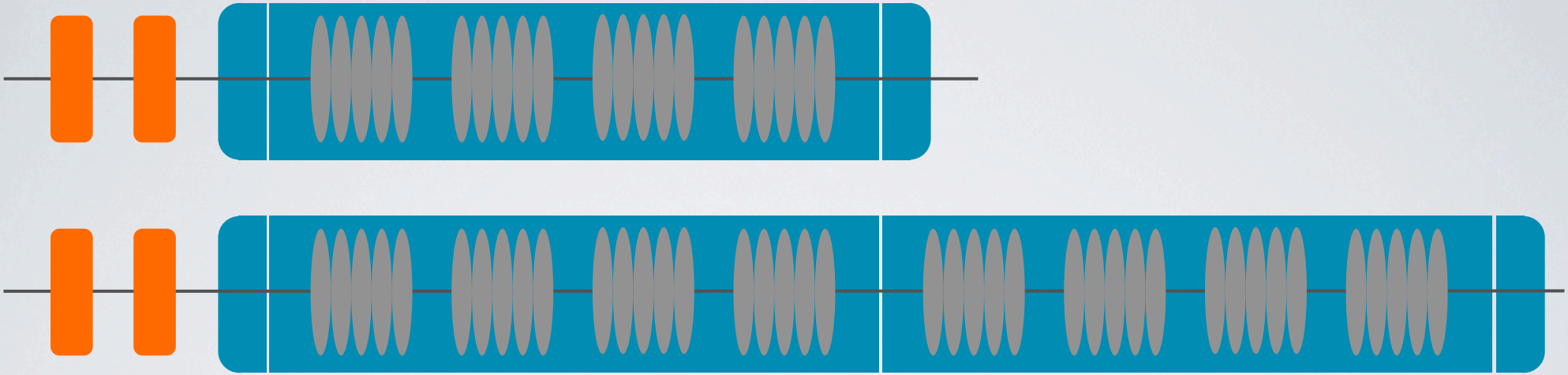
Optimized for 50 mA

C.MQ.MCR.1	Beta_Geo	No of Cryos	Length	No of Cavities	No of Quads
Spokes	0.54	17	69.2	51	34
Low Beta	0.75	8	55.9	32	16
High Beta	0.75	40 / 2	239.7	160	40
Total	--	17 + 48	69.2 + 295.6	51 + 192	34 + 56

Optimized for 75 mA

High Beta 50	0.75	38 / 2	227.7	152	38

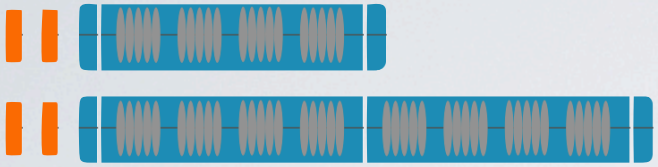
1 BETA WARM MOD.



W.SQ.MCR.1	Beta_Geo	No of Cryos	Length	No of Cavities	No of Quads
Spokes	0.54	20	81.4	60	40
Low Beta	0.82	8	57.5	32	16
High Beta	0.82	28 / 2	174.7	112	28
Total	--	20 + 36	81.4 + 232.2	60 + 144	40 + 44

High Beta 75	0.82	40 / 2	249.6	160	40

1 BETA WARM MOD. HP



Cryo to Quad	mm	150	Cryo to Cavity	mm	300
Quad to Quad	mm	400	Cavity to Cavity	mm	400
Quad to Cryo	mm	150	Cavity to Cryo	mm	300
Front-Cap	mm	200	End-Cap	mm	200

Optimized for 50 mA

W.SQ.MCR.1	Beta_Geo	No of Cryos	Length	No of Cavities	No of Quads
Spokes	0.53	17	68.5	51	34
Low Beta	0.75	9	62.0	36	18
High Beta	0.75	40 / 2	237.7	160	40
Total	--	17 + 48	68.5 + 299.7	51 + 192	34 + 56

Optimized for 75 mA

High Beta 50	0.75	36 / 2	213.0	144	36

COMPARISON (50@50)

	Geometric β Spk / Lβ / Hβ	No. of Cavities Spk / Lβ / Hβ	No. of Cryos Spk / Lβ / Hβ	Length (m) Spk / Lβ / Hβ	No. of Quads Spk / Lβ / Hβ
C.CQ.DCR.2	0.54 / 0.67 / 0.84	48 / 36 / 112 (0)	16 / 9 / 14	65 / 53 / 169 (0)	32 / 18 / 28
C.SQ.DCR.2	0.53 / 0.66 / 0.84	54 / 28 / 120 (6)	18 / 7 / 15	73 / 50 / 196 (32)	36 / 14 / 30
W.SQ.DCR.2	0.54 / 0.68 / 0.85	48 / 36 / 112 (0)	16 / 9 / 14	65 / 59 / 174 (11)	32 / 18 / 28
C.SQ.UCR.1	0.53 / 0.82 / 0.82	57 / 36 / 112 (9)	19 / 9 / 28x0.5	77 / 70 / 187 (44)	38 / 18 / 28
W.SQ.UCR.1	0.54 / 0.82 / 0.82	60 / 32 / 112 (8)	20 / 8 / 28x0.5	81 / 57 / 177 (28)	40 / 16 / 28
C.MQ.MCR.1	0.54 / 0.82 / 0.82	60 / 32 / 112 (8)	20 / 8 / 28x0.5	81 / 58 / 176 (28)	40 / 16 / 28
W.SQ.MCR.1	0.54 / 0.82 / 0.82	60 / 32 / 112 (8)	20 / 8 / 28x0.5	81 / 58 / 175 (26)	40 / 16 / 28

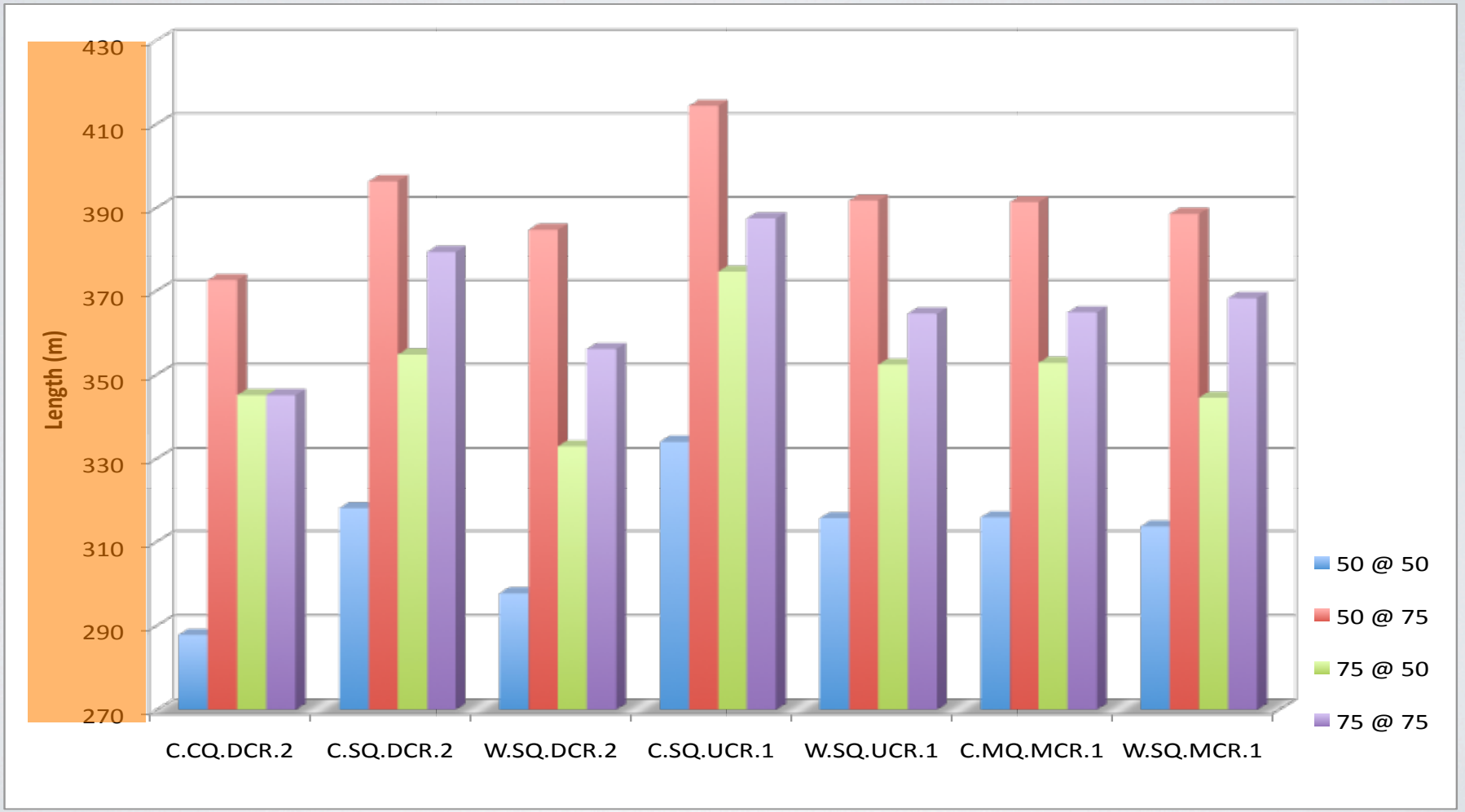
Numbers in the parentheses show the difference from the best case

COMPARISON (75@75)

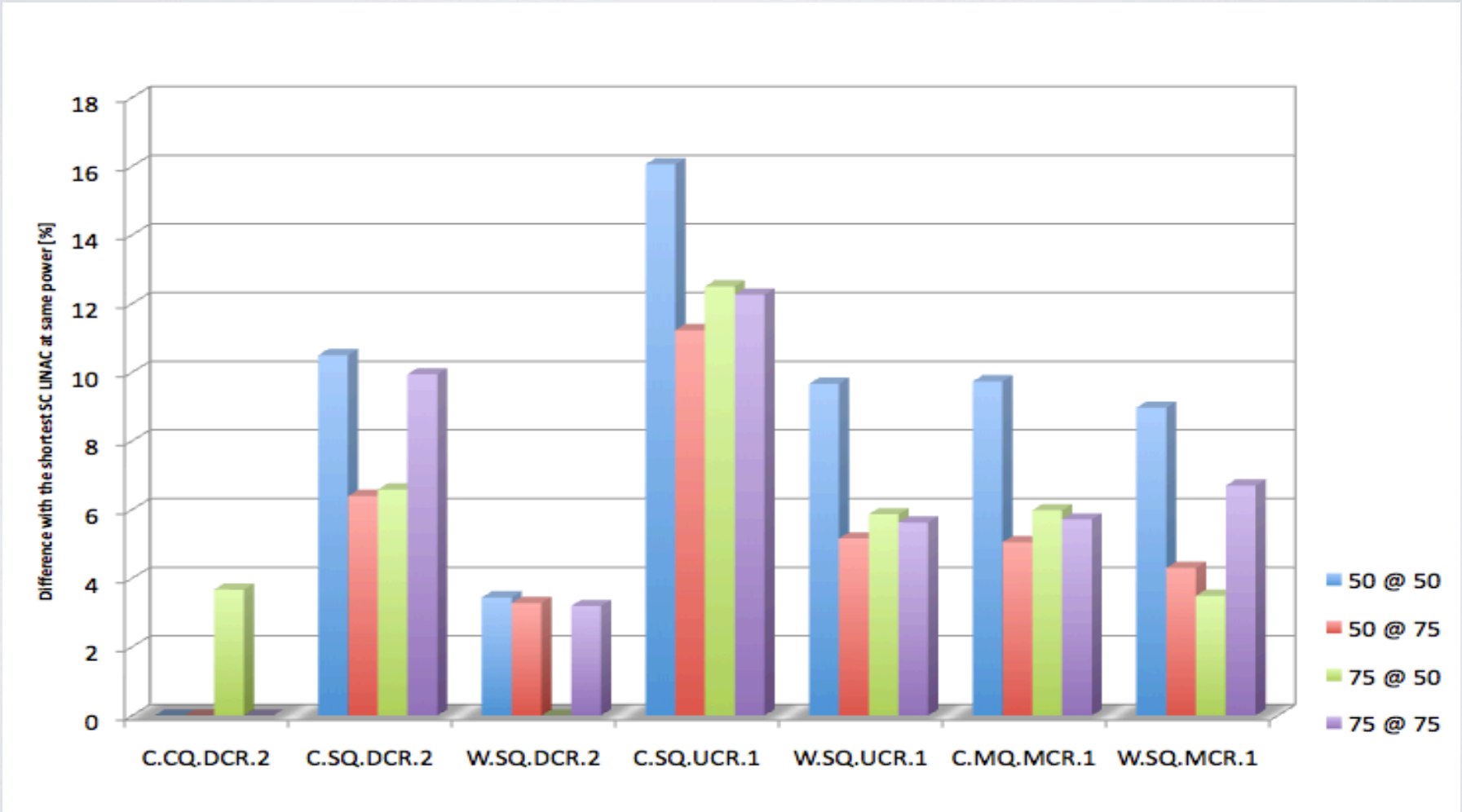
	Geometric β Spk / Lβ / Hβ	No. of Cavities Spk / Lβ / Hβ	No. of Cryos Spk / Lβ / Hβ	Length (m) Spk / Lβ / Hβ	No. of Quads Spk / Lβ / Hβ
C.CQ.DCR.2	0.51 / 0.63 / 0.75	42 / 36 / 168 (3)	14 / 9 / 21	55 / 52 / 238 (0)	28 / 18 / 42
C.SQ.DCR.2	0.53 / 0.66 / 0.75	48 / 32 / 168 (5)	16 / 8 / 21	64 / 57 / 258 (34)	32 / 16 / 42
W.SQ.DCR.2	0.53 / 0.64 / 0.75	51 / 28 / 168 (4)	17 / 7 / 21	69 / 44 / 243 (11)	34 / 14 / 42
C.SQ.UCR.1	0.54 / 0.76 / 0.76	57 / 28 / 160 (2)	19 / 7 / 40x0.5	77 / 53 / 257 (43)	38 / 14 / 40
W.SQ.UCR.1	0.53 / 0.75 / 0.75	51 / 32 / 160 (0)	17 / 8 / 40x0.5	69 / 54 / 242 (19)	34 / 16 / 40
C.MQ.MCR.1	0.54 / 0.75 / 0.75	51 / 32 / 160 (0)	17 / 8 / 40x0.5	69 / 56 / 240 (20)	34 / 16 / 40
W.SQ.MCR.1	0.53 / 0.75 / 0.75	51 / 36 / 160 (4)	17 / 9 / 40x0.5	69 / 62 / 238 (23)	34 / 18 / 40

Numbers in the parentheses show the difference from the best case

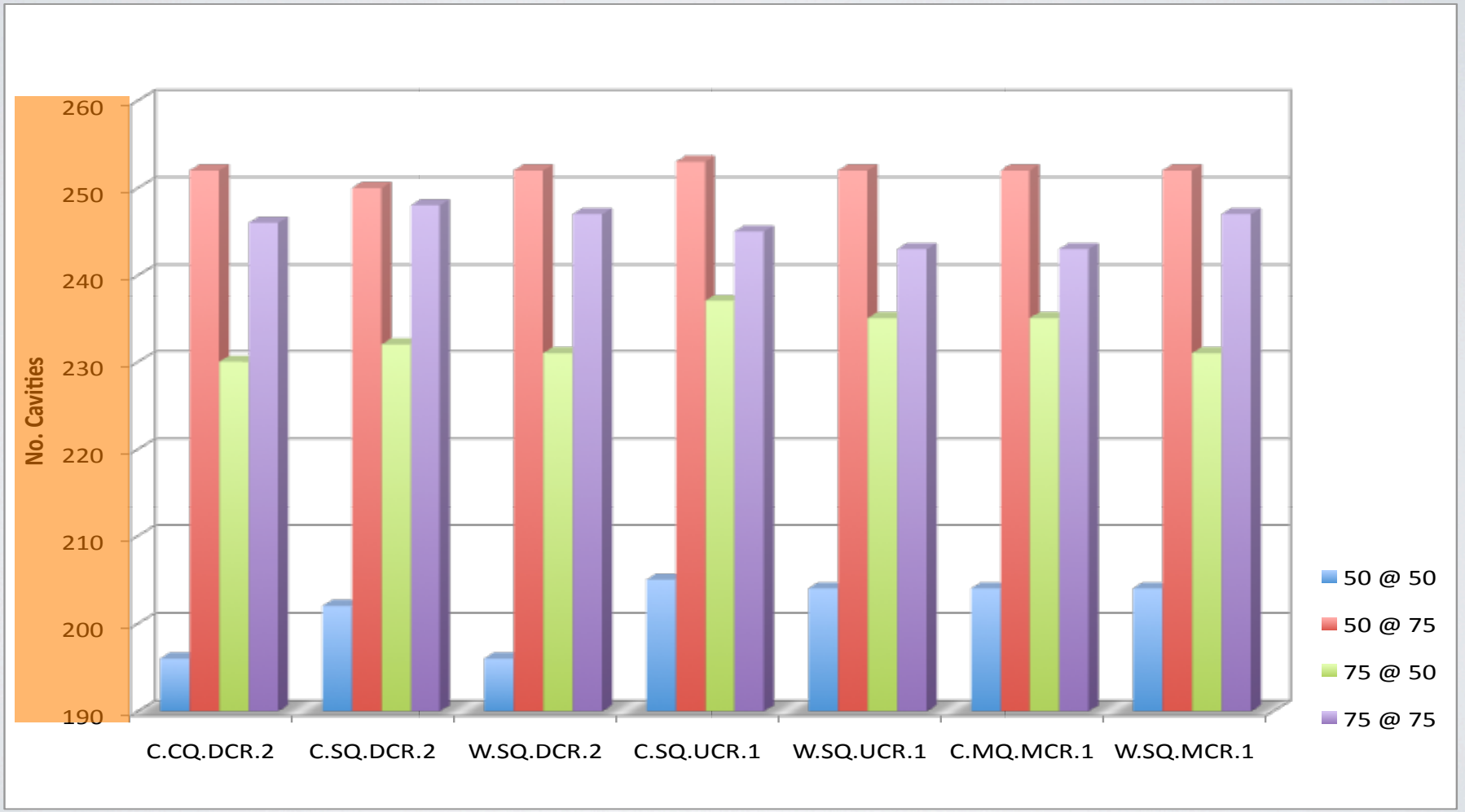
LENGTH COMPARISON



LENGTH COMPARISON [%]

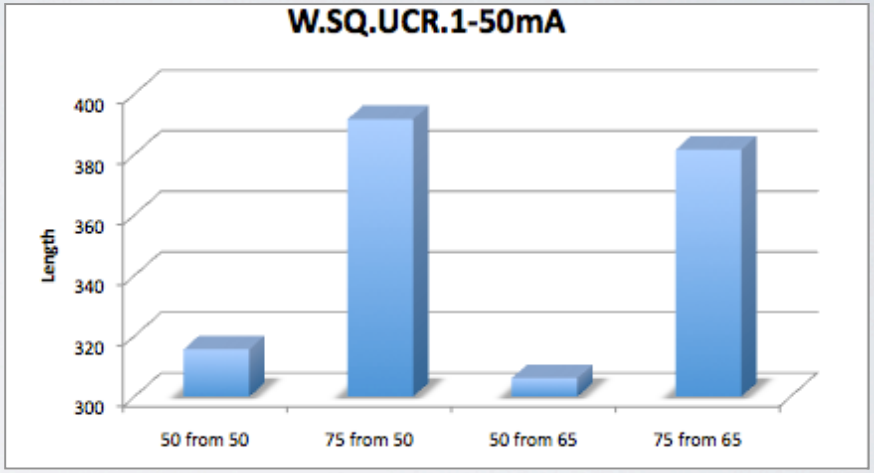


CAVITY INVENTORY

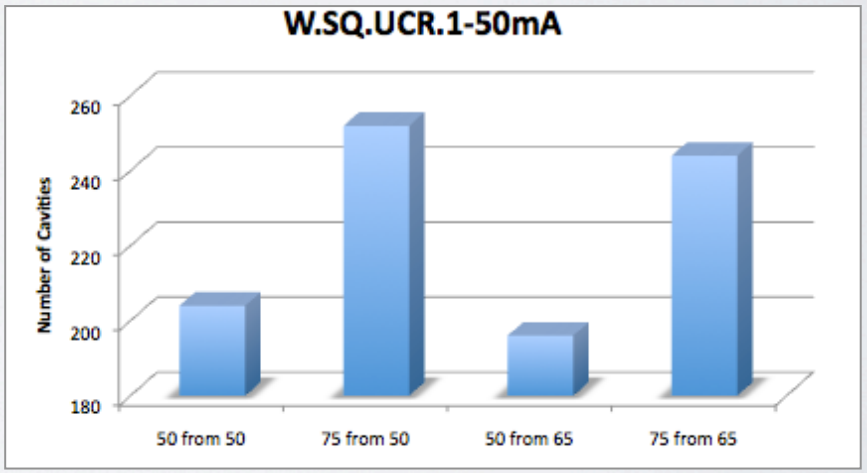


SC INPUT ENERGY?!

Increasing the input energy by 15 MeV in DTL requires almost the same length as we save in spokes.



Increasing the input energy to Spoke resonators to 65 MeV reduces the number of spoke cavities by 6.



exotic ALTERNATIVE SOLUTION

Disclaimer

Contents of this and following slide are not in ESS official or nonofficial roadmap

- Assumption and dreams:
  - There might be a second target
  - Neutron scientists are already thinking of 15 MW
- Proposed Solution
  - ~~Drop the 7.5 MW upgrade possibility~~
  - Increase the power to 15MW in an independent LINAC

SCALED ON FIELD

Length: 410 m
No of Cavities 288
No of Cryos: 36
No of Quads: 36

SUMMARY

- Seven cryo-module architectures are proposed for SC LINAC
- In four architectures just one type of elliptical cavities is used
- Architectures are compared on their length and inventory
- An exotic design is proposed for a hypothetical ultra-high power LINAC

Thank you for your attention