CHANGE OF D1 LENGTH AND FIELD

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On behalf of T. Nakamoto, Q. Xu
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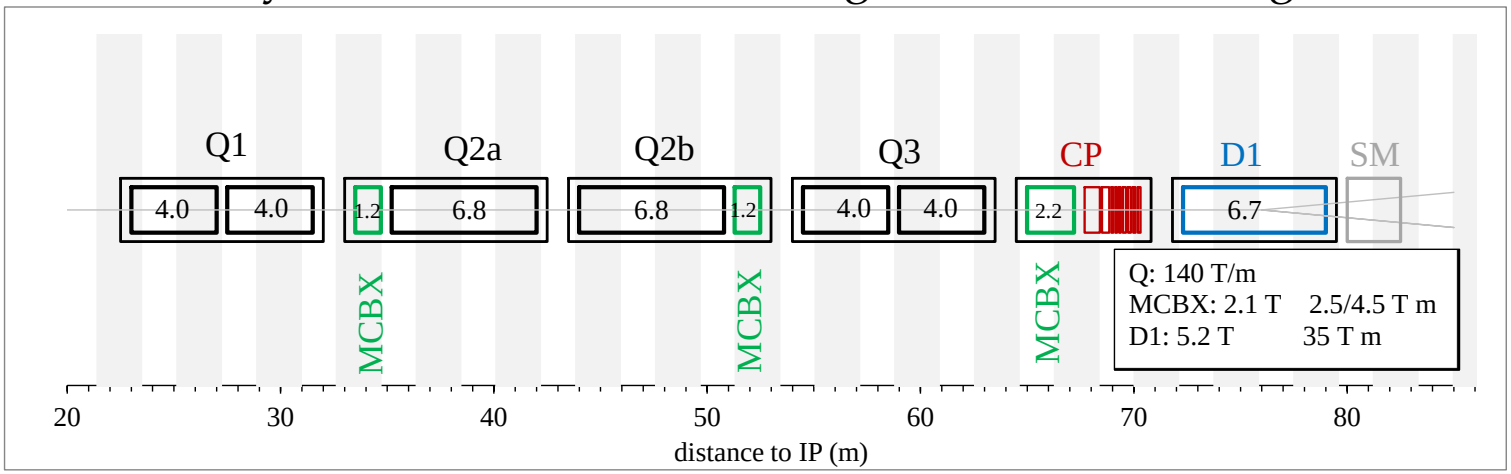
BASELINE

- D1 is the separation dipole
  - Superconductive, Nb-Ti, large aperture
  - Started with 160 mm aperture, then decided that 10 mm more than quads was not needed after ebergy deposition studies
- 35 Tm required
  - 70% margin on the loadline was chosen, giving 5.2 T operational field with 15 mm one layer coil
    - Two layers excluded since this magnet has a lot of fringe field already



Field verus coil width in accelerator magnets and models
[E. Todesco, L. Rossi Malta workshop CERN 2011-003]

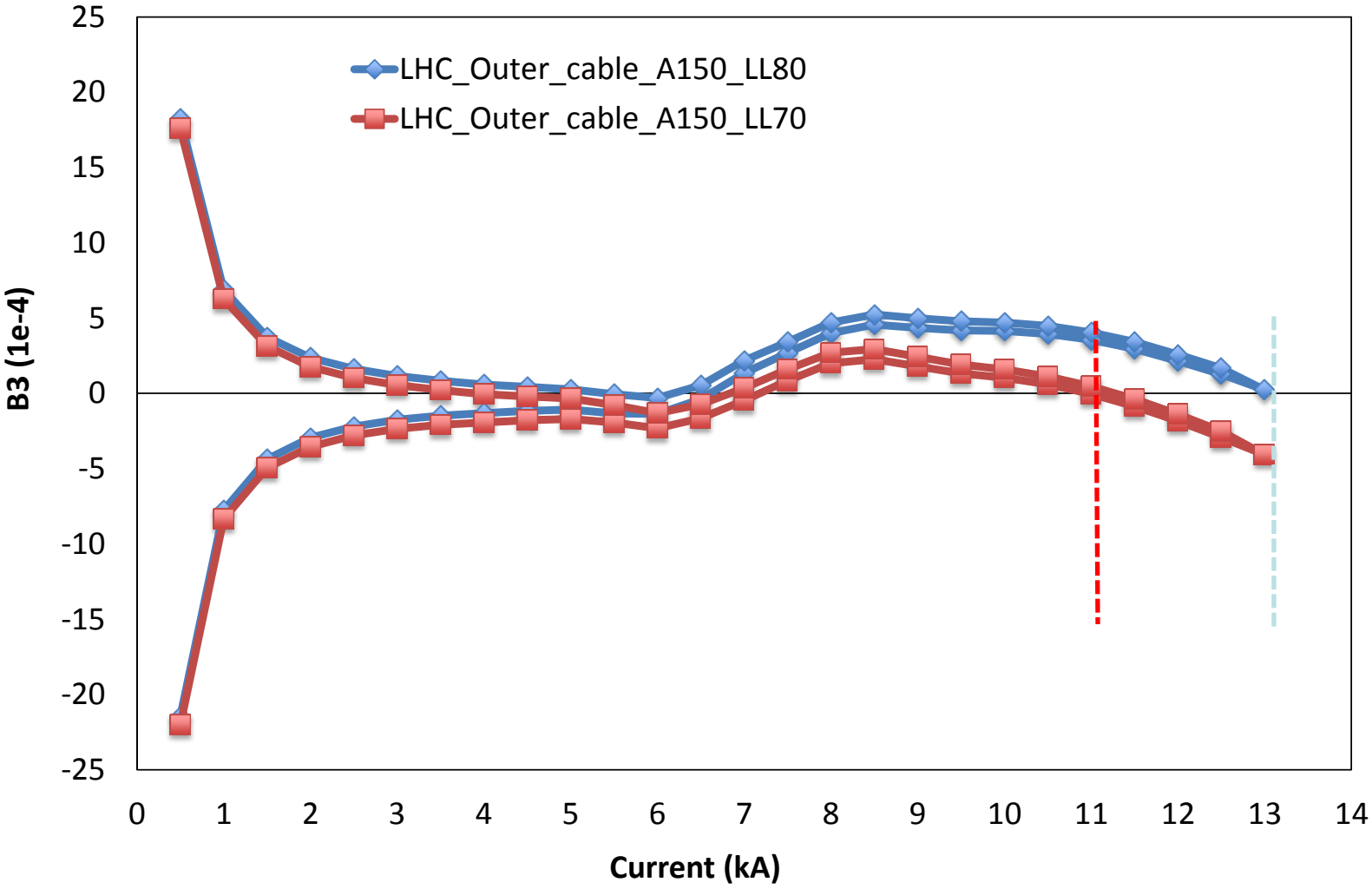
VARIATIONS

- The chosen margin is large w.r.t. quadrupoles, which are in Nb3Sn and in similar region for radiation and heat loads
  - Possible to decrease from 30% to 20-25%
- At the same time the length corresponding to 5.2 T and 35 Tm was exceeding the vertical test station length at KEK
  - Study was carried out to explore the case of 25% margin and 20% margin
  - Options look viable, with increase of stress and fring field which appears to be tolerable [talk on 25 June 2013, T. Nakamoto and Q. Xu]

THREE OPTIONS AT 150 MM

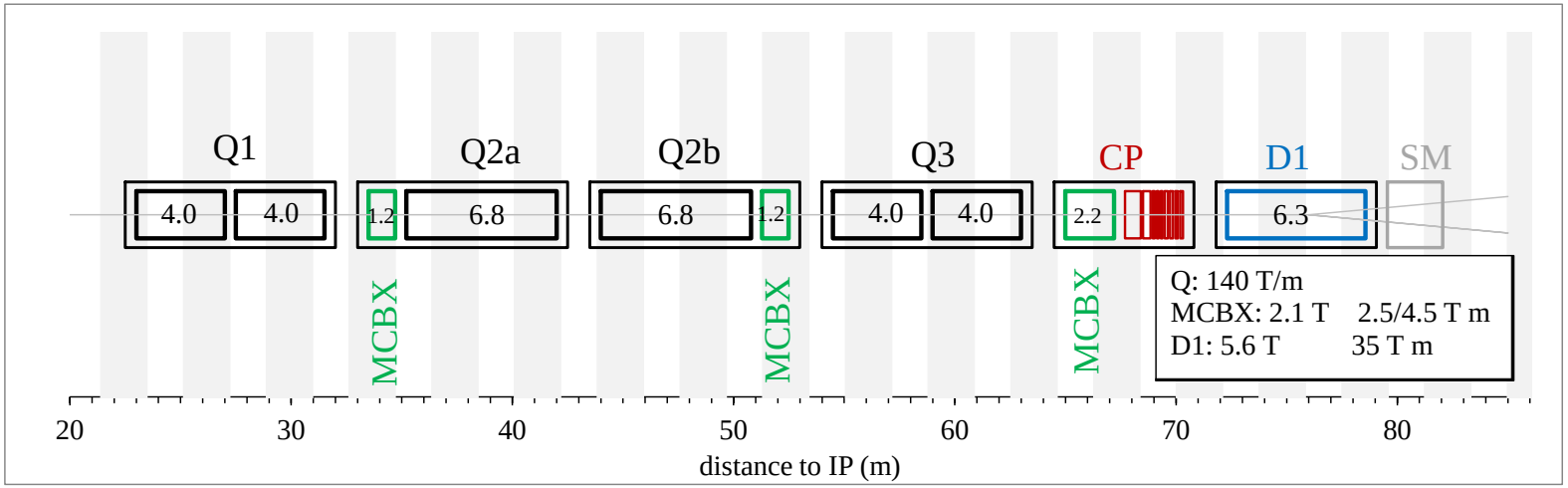
	LHC outer cable With 70% load line ratio	LHC outer cable With 75% load line ratio	LHC outer cable With 80% load line ratio
Bore diameter	150 mm	150 mm	150 mm
Nominal field (dipole)	**5.22 T**	**5.59 T**	**5.97 T**
Magnetic length *	**6.7 m**	**6.3 m**	**5.9 m**
Operating current	**11.0 kA**	**12.0 kA**	**13.0 kA**
Injection current	~ 0.70 kA	~ 0.77 kA	~ 0.84 kA
Field homogeneity	<0.01% (R_{ref}=50 mm)	<0.01% (R_{ref}=50 mm)	<0.01% (R_{ref}=50 mm)
Peak field in the coil	6.0 T	6.5 T	6.9 T
Load line ratio	69% @ 1.9 K	75% @ 1.9 K	80% @ 1.9 K
Inductance (low / nominal field)	5.7 / 5.2 mH/m	5.7 / 5.2 mH/m	5.7 / 5.1 mH/m
Stored energy	**294 kJ/m**	**340 kJ/m**	**391 kJ/m**
Peak field/central field	1.15	1.15	1.16
Lorenz force X/Y (1st quadrant)	**1.3/0.5 MN/m**	**1.5/0.6 MN/m**	**1.7/0.7 MN/m**
Outer dia. of iron yoke	550 mm	550 mm	550 mm
Inner dia. of iron yoke	222 mm	222 mm	222 mm
Strand diameter	0.825 mm	0.825 mm	0.825 mm
Cu/Non-Cu ratio	1.95	1.95	1.95
Cable dimension / insulation	**15.1* 1.48mm²** / 0.16 mm (radial) 0.145 (azimuthal)	**15.1* 1.48mm²** / 0.16 mm (radial) 0.145 (azimuthal)	**15.1* 1.48mm²** / 0.16 mm (radial) 0.145 (azimuthal)
No. of strands	36	36	36
Keystone angle	0.9 °	0.9 °	0.9 °
Superconductor current density	1710 A/mm²	1865 A/mm²	1954 A/mm²
Total length of the cable	**618 m (Coil length ~7.1 m)**	**566 m (Coil length ~6.7 m)**	**548 m (Coil length ~6.3 m)**

IMPACT ON FIELD QUALITY



CONCLUSIONS

- We propose to reduce the margin from 30% to 25%, i.e. increasing the operational field from 5.2 to 5.6 T and reducing length from 6.7 to 6.3 m
  - Minimal change needed to fit the test station
  - Current increase from 11 to 12 kA



SUMMARY

		Triplet Q1,Q3/Q2a,b	Orbit corrector MCBX	Sep. dipole D1	Recom. dipole D2	Large 2-in-1 quad Q4
Aperture	(mm)	150	150	150	105	90
Field	(T)		2.1	5.6	3.5	
Gradient	(T/m)	140				120
Mag. Length	(m)	8.0/6.8	1.2/2.2	6.3	10.0	4.5
Int field	(T m)		2.5/4.5	35	35	
Int gradient	(T)	1120/938				544
Peak field	(T)	12.1	3.9	6.5	4.1	5.9
Current	(kA)	17.5	2.2	11.8	6.8	16.0
j overall	(A/mm^2)	528	455	1816	1040	2458
Loadline margin	(%)	18%	45%	25%	56%	20%
Stored energy	(MJ/m)	1.440	0.090	0.338	0.140	0.204
Saturation	(%)	9.0%	0.0%	12.0%	13.0%	
Material		Nb_3Sn	Nb-Ti	Nb-Ti	Nb-Ti	Nb-Ti
N. layers		2	1+1	1	1	1
Cable width	(mm)	18.1	4.37	15.1	15.1	15.1