HL LHC LAYOUT FROM INTERACTION POINT TO SEPARATION DIPOLE

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Acknowledgements: B. Dalena, M. Giovannozzi, R. De Maria, S. Fartoukh, B. Holzer, P. Fessia, M. Karppinen, A. Ballarino, J. P. Burnet, R. Ostojic, H. Prin, F. Toral, D. Ramos

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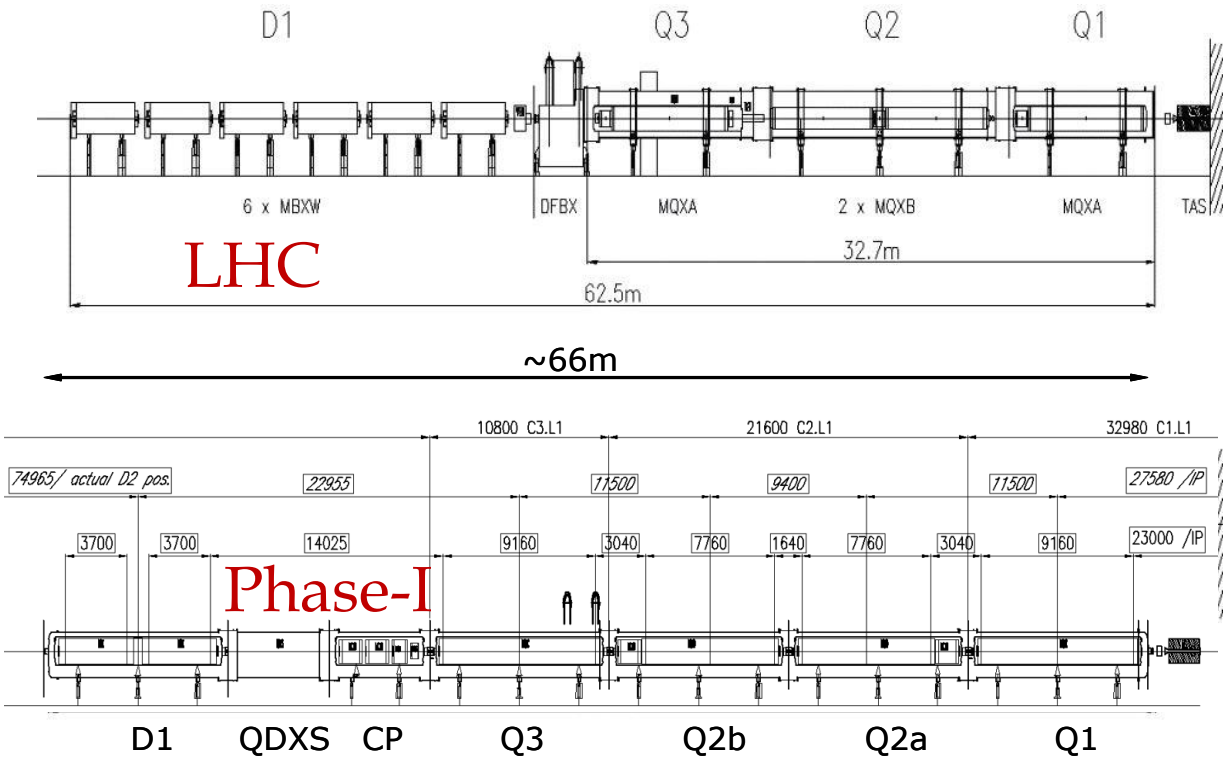
WHERE ARE WE

- January 2012
  - Preliminary exploration of 4 layouts (120/140 mm, Nb-Ti and Nb_3Sn), both triplet and separation dipole
- July 2012
  - Aperture and technology selection, 150 mm Nb_3Sn
- Summer 2012
  - Estimates of heat load, shielding and cooling
  - Target of 40 MGy, 5 mW/cm^3 possibly reduced to 20 Mgy
    - So same levels as in LHC – please remember
- Fall 2012
  - Conceptual design correctors
- Winter 2012-2013:
  - Powering, interconnections, layout from IP to D1

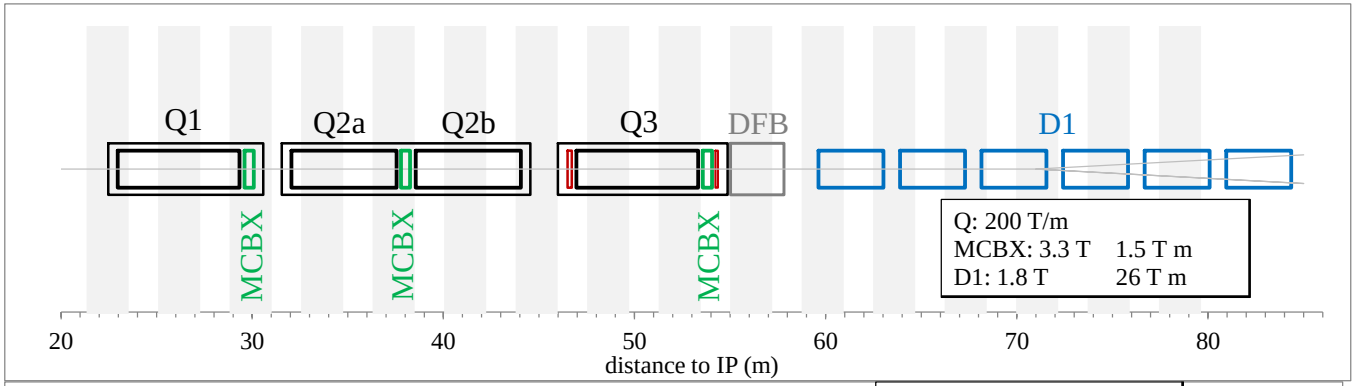
LAYOUTS



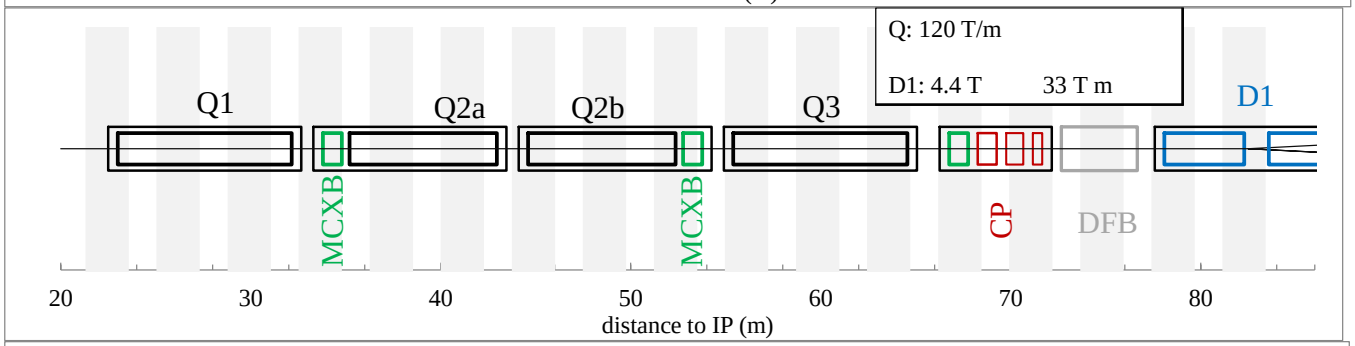
Layout of Phase I and LHC [R. Ostojic, S. Fartoukh, Chamonix 2010]

LAYOUTS

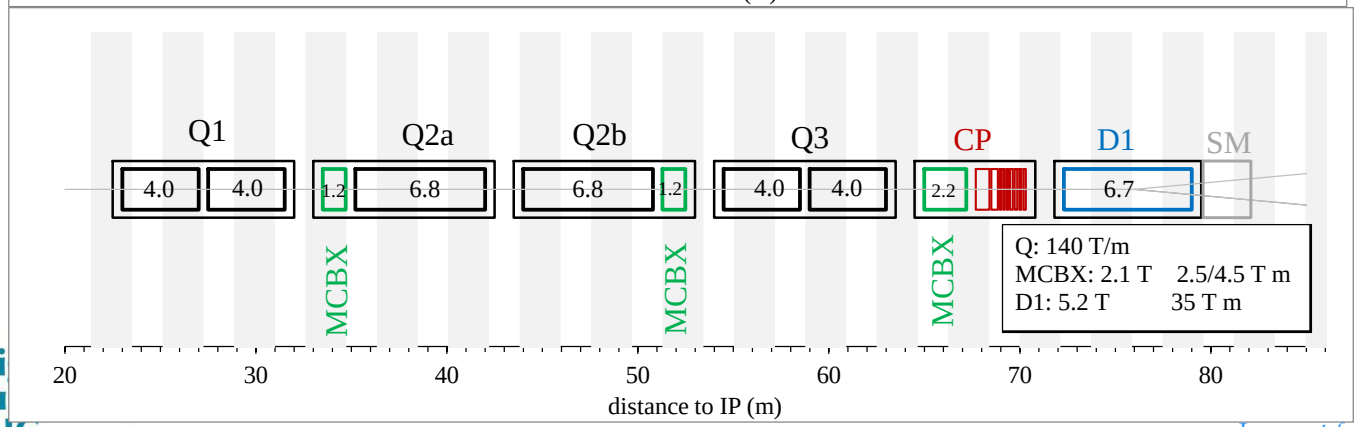
Thick boxes are magnetic lengths
Thin boxes are cryostats



LHC

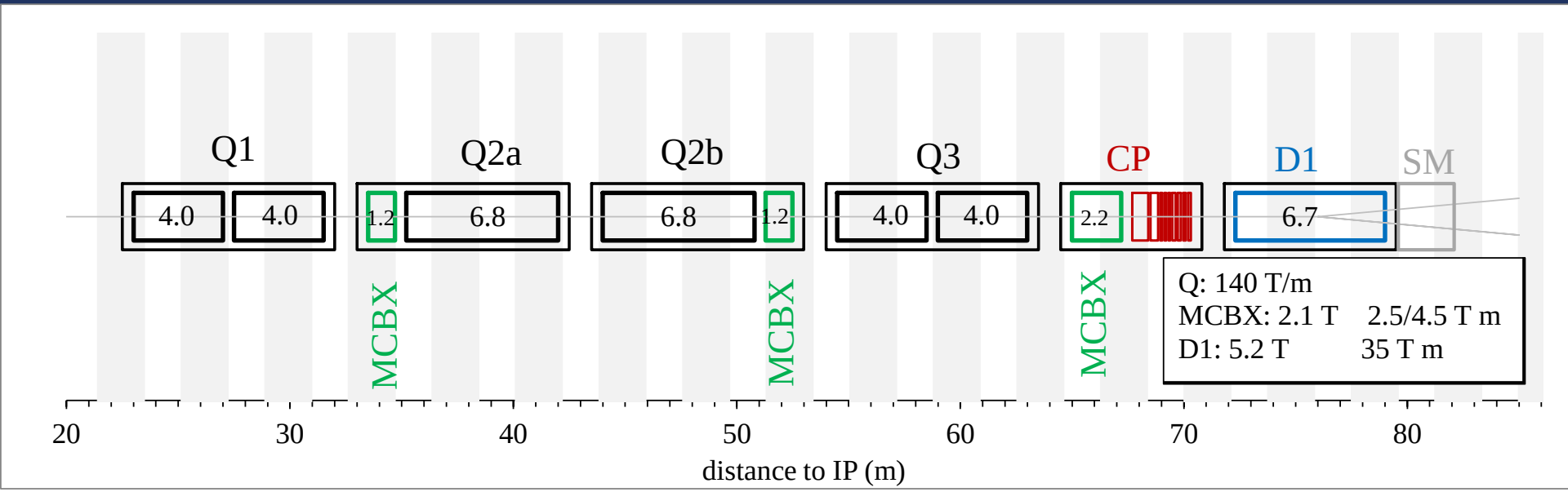


Phase I



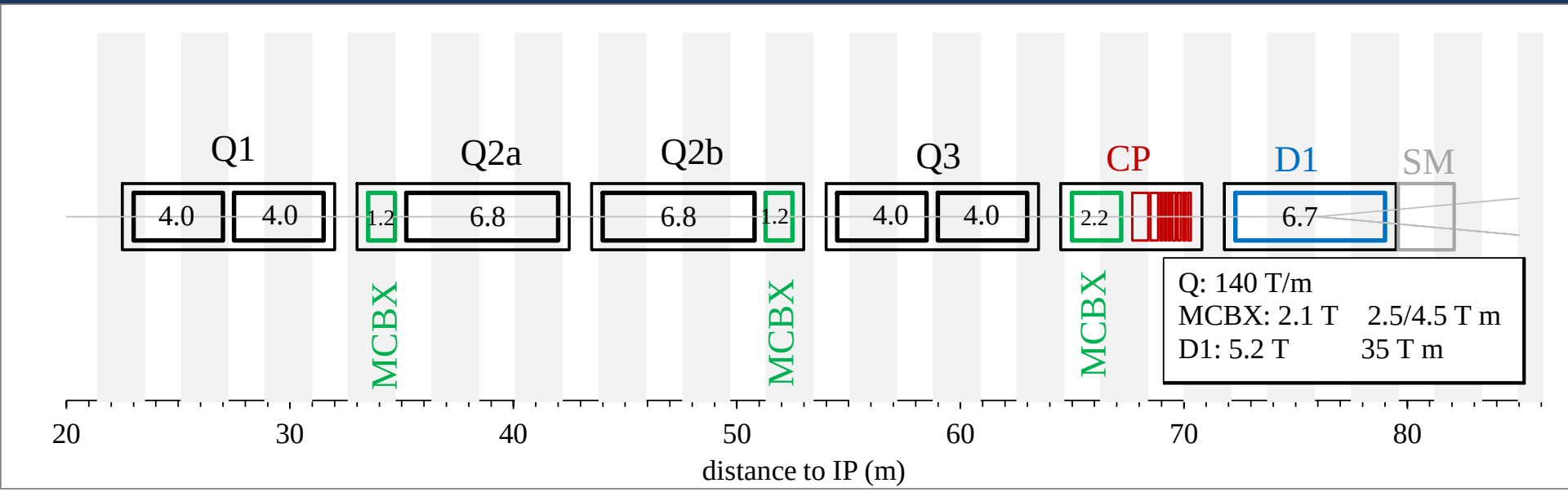
HL LHC

QUADRUPOLES

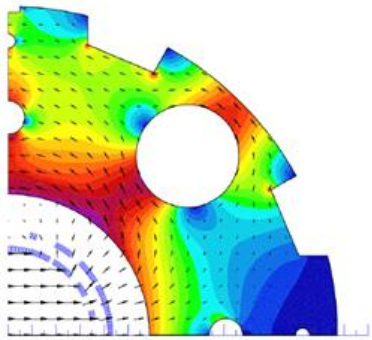


- 150 mm aperture, 140 T/m, Q1 and Q3 split in two
  - 0.5 m between split cold masses (Q1 and Q3)
  - 0.5 m between end of magnetic length and end of the cryostat
  - Substantial design work ongoing to [P. Ferracin, G. Ambrosio, H. Felice, F. Borgnolutti, S. Izquierdo, M. Juchno, H. Prin …]
- Cryostat choices:
  - We keep symmetry and modularity (two types only)
  - Alternative: reducing number of cryostats from 4 to 3

ORBIT CORRECTORS

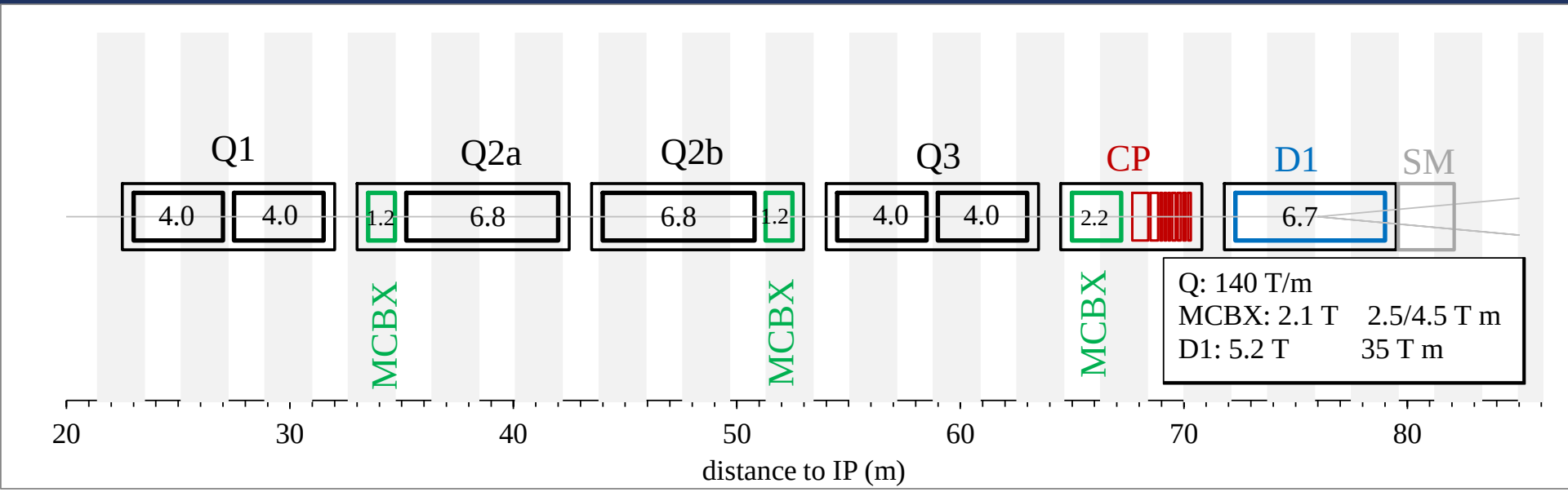


- Requirement is to have 2.5 T m around Q2, and 4.5 T m between Q3 and D1
  - Nested option to save space (4 m)
  - 2.1 T given by 50% margin with Mikko 4.6 mm width cable, one layer
    - So 1.2 m and 2.2 m respectively allocated

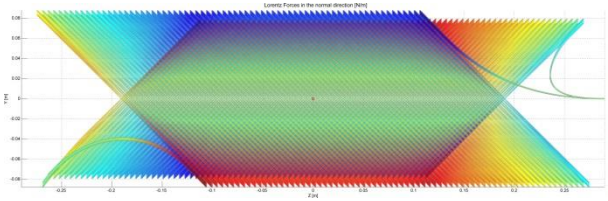


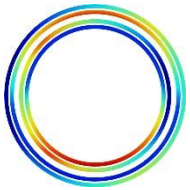
Proposal for nested MCBX (M. Karppinen)

ORBIT CORRECTORS



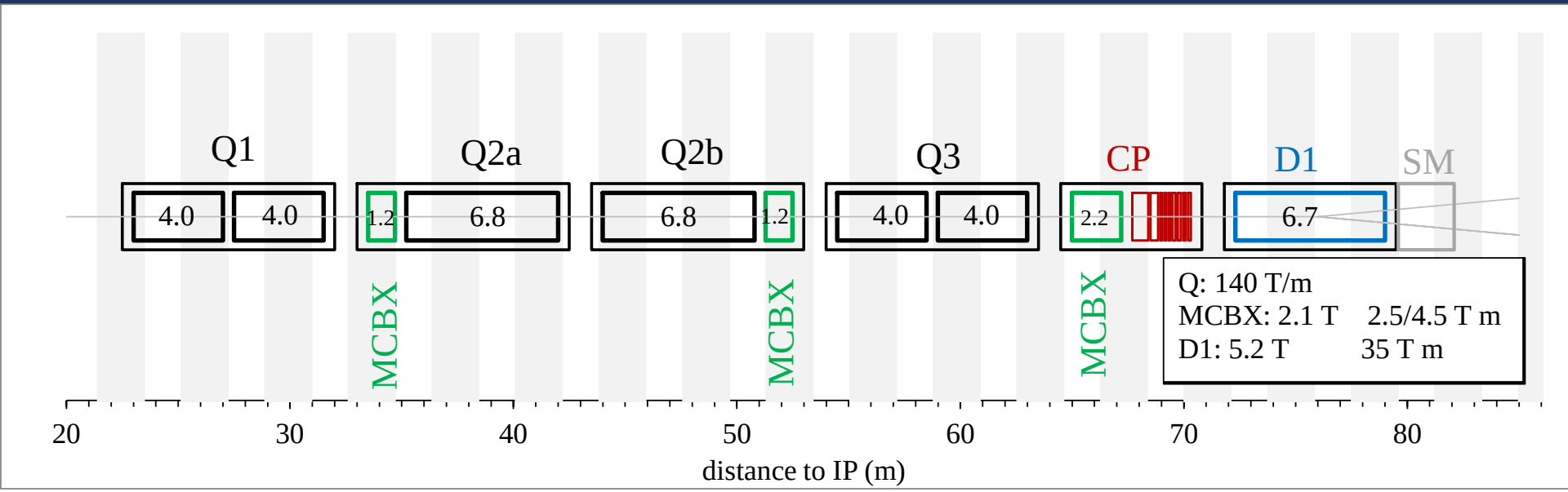
- Alternative options
  - I would exclude design with two layers, 4 T, saving 2 m but having 4 times torque
  - Canted dipole ? – Some preliminary work being done





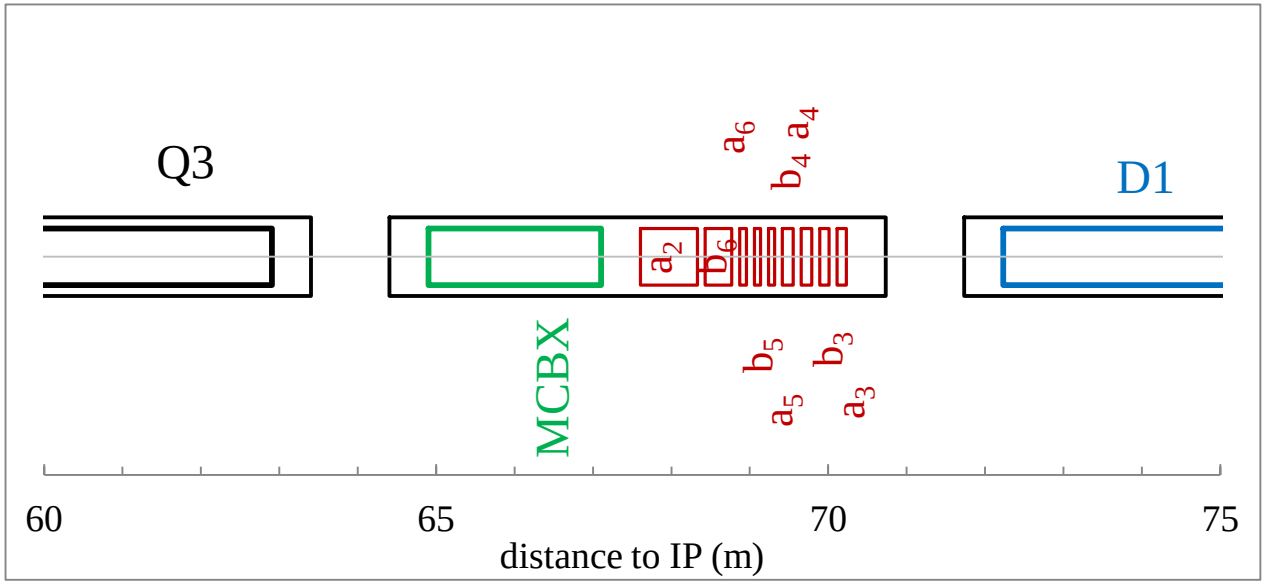
Proposal for canted dipole [J. V. Nutgeren, S. Caspi]

NON LINEAR CORRECTORS



- Superferric option, no nested, max saturation of 20% TF
  - We satisfy the ABP requirements including a safety factor 2 for order 2,3,4 and a factor 1.5 for 5 and 6 corrector strength [F. Toral]
  - Typical length of 100 mm – short coil ends
  - Longer: skew quadrupole (730 mm) and b_6 (350 mm)
  - a_2, b_3, a_3, b_4, a_4, b_5, a_5, b_6, a_6: nine objects
  - Assume 100 mm distance coil to coil (80 mm magnet to magnet) – Total length is 2.5 m

NONLINEAR CORRECTORS

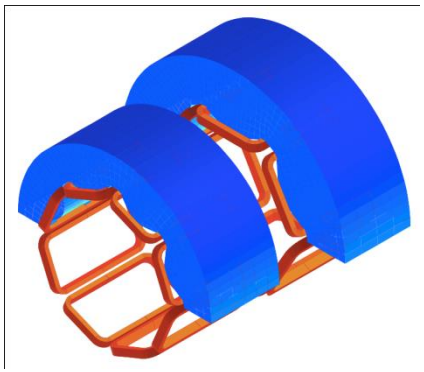


Name	Multipole	Coil length (m)	Force (T m)
MCQSX3	a_2	0.728	1.0000
MCTX3	b_6	0.339	0.0860
MCTSX3	a_6	0.087	0.0168
MCDX3	b_5	0.079	0.0254
MCDSX3	a_5	0.079	0.0254
MCOX3	b_4	0.137	0.0458
MCOSX3	a_4	0.137	0.0458
MCSX3	b_3	0.121	0.0625
MCSSX3	a_3	0.121	0.0625

- Requirements based on tracking studies [M. Giovannozzi et al]
- Problem of longitudinal

  cross-talk being studied

  [F. Toral, B. Auchmann]



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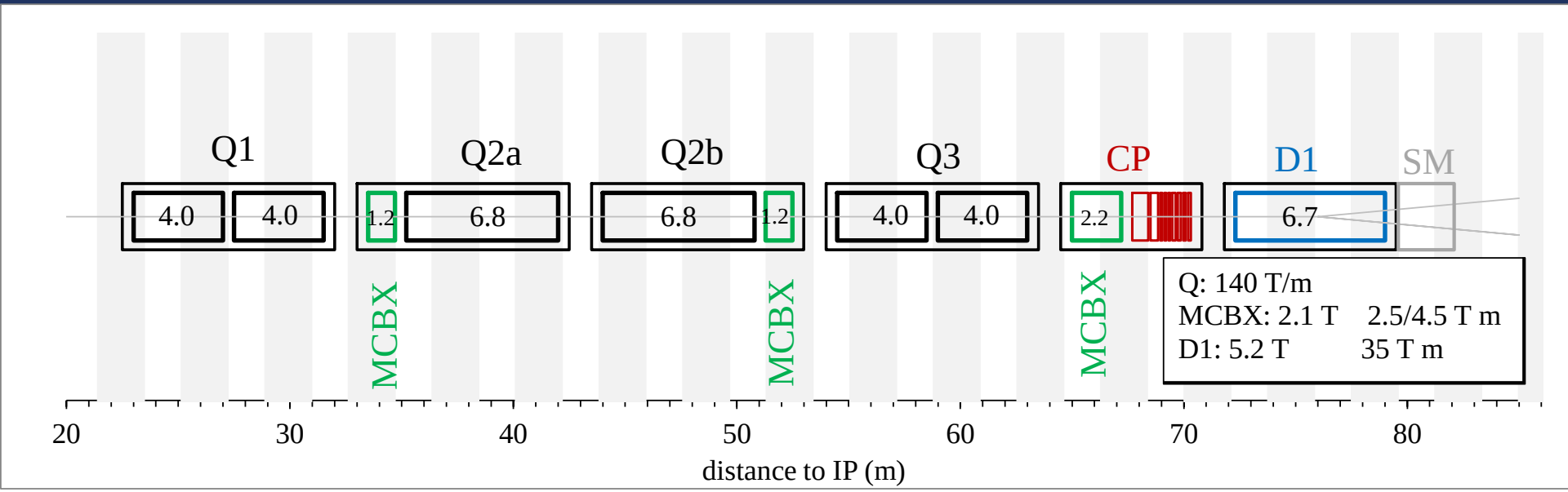
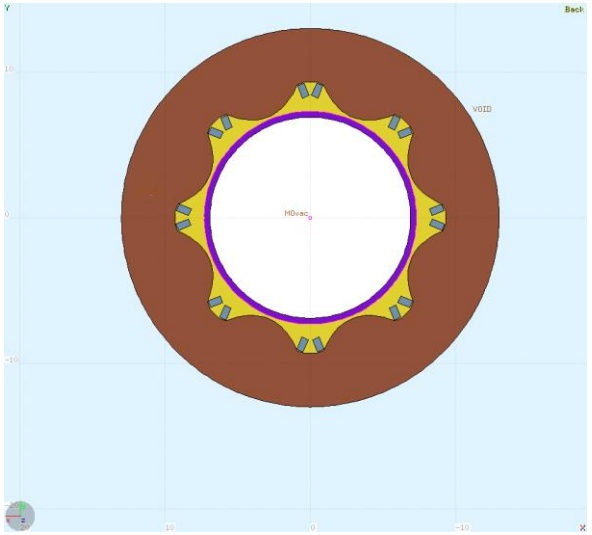
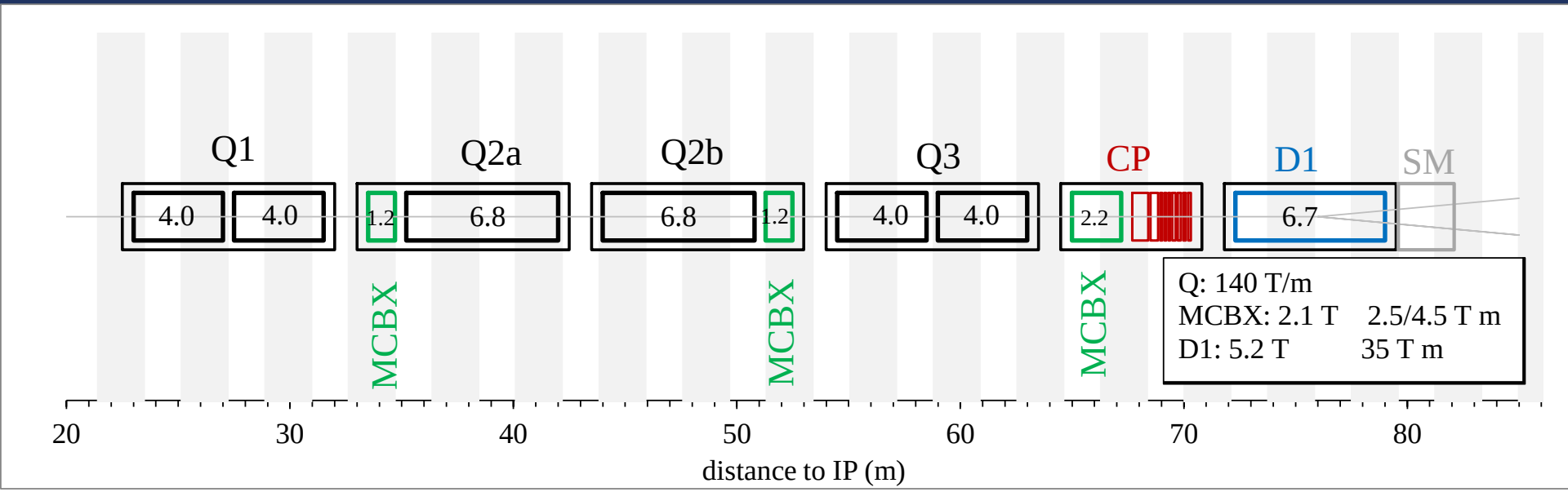


- Advantages
  - Not nested – easier operation
  - Very short heads (20 mm)
  - Very robust to radiation
- Alternative options
  - LHC design – larger field so shorter magnet
  - But longer heads

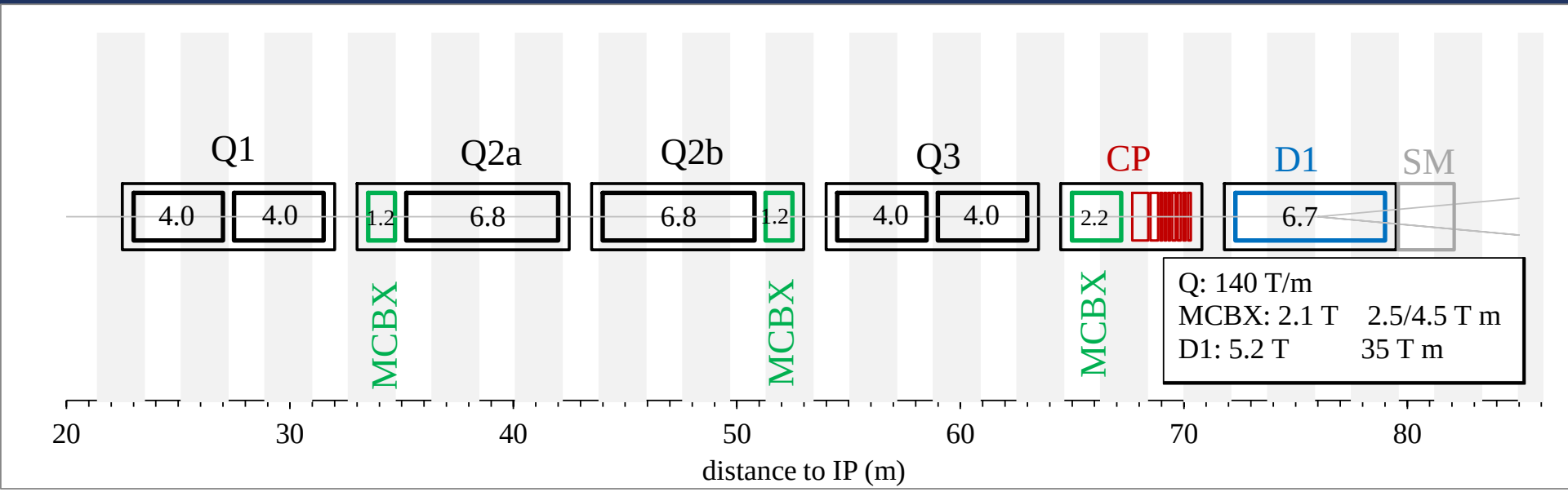


SEPARATION DIPOLE D1



- 35 T m required
  - Assuming one layer of MB dipole cable, 5.2 T at 70% on the loadline – less than 6.7 m long [Q. Xu, T. Nakamoto]
  - One layer reduces fringe field
  - Alternative options: two layers, or reduce margin (in both cases we gain 1-2 m)
    - I would wait to know heat load – first results coming in the next weeks

BPM POSITION



- Grey lines: position to avoid for BPM
  - Multiple of 3.74 m [J. P. Koutchouk, R. Jones, and S. Fartoukh]
    - Allowable band width ~1.5 m around optimal position – to be assessed
  - So they are all ok except the last one between CP and D1

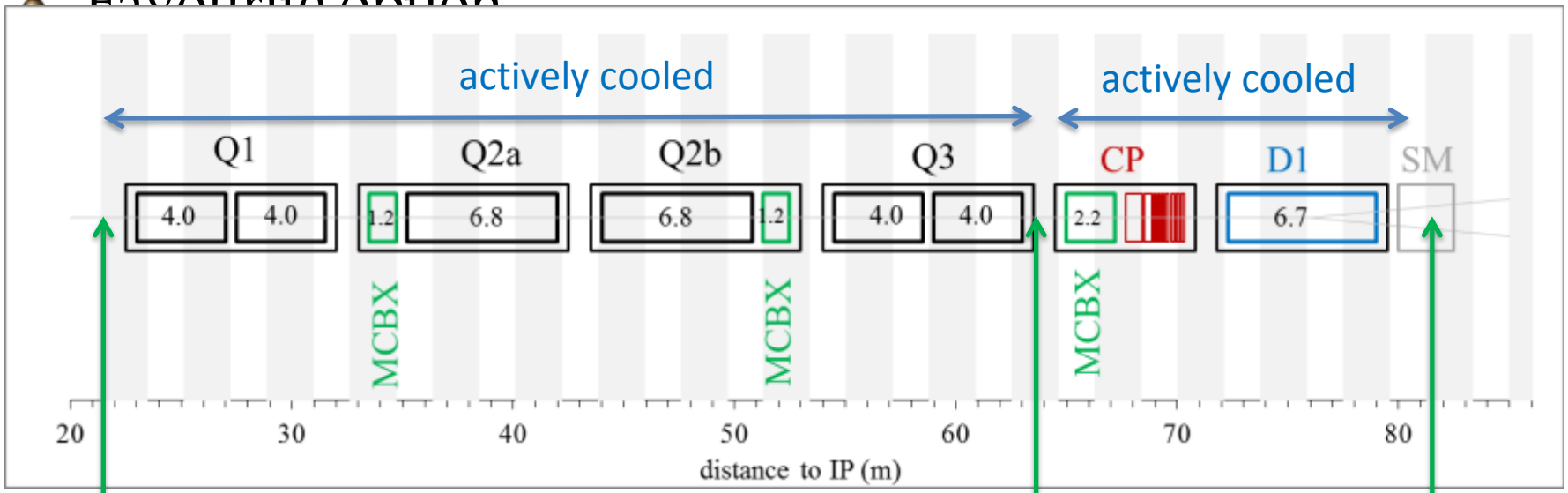
CURRENTS AND POWERING

- Currents
  - Quadrupoles: 17 kA (four circuits or one plus two trims)
  - Corrector dipole: 2.4 kA (two times three circuits)
  - Nonlinear correctors: 100 A (nine cicuits)
  - Separation dipole: 11 kA (outer dipole cable)

- Cooling [R. Van Weelderen]
  - Triplet and orbit correctors: two HX, 80 mm, at 45 degrees
  - Best option: a separate HX for D1 and corrector package

CURRENTS AND POWERING

- Favourite option



- Phase-separator &
- Piping entries/exits

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- Possible QRL-jumper

- SM &
- QRL-jumper
- Phase-separator
- Piping entries/exits

Q1,Q2a,Q2b,Q3: actively cooled for about 41 m, double-HXs needed
CP,D1 : actively cooled for about 16 m, double-HXs needed

High Luminosity LHC

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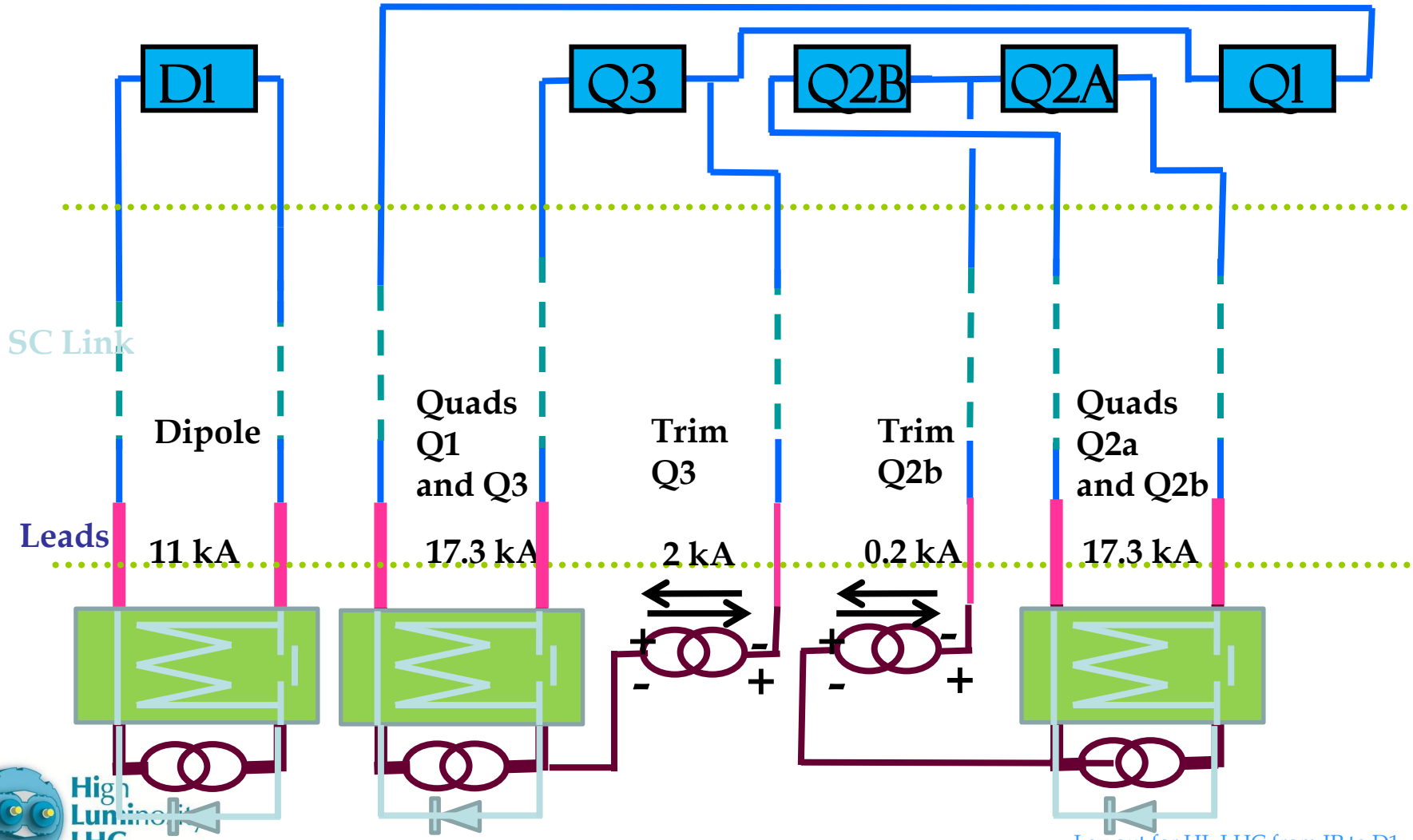
Currents and Powering

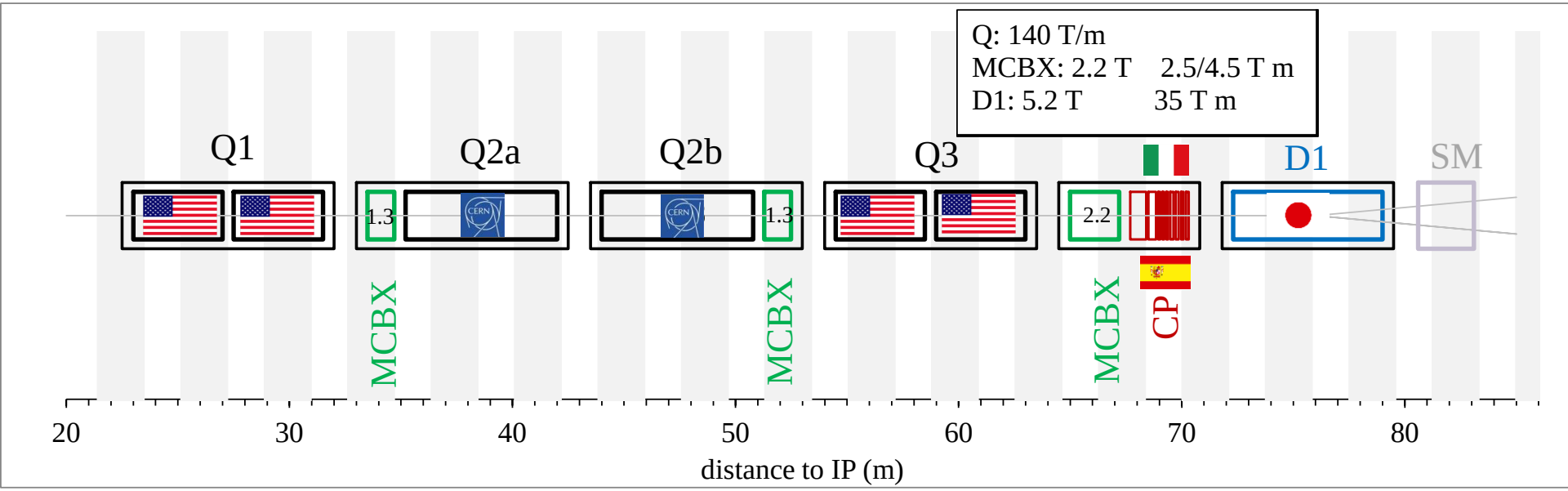
- Three possibilities for the triplet
  - One power converter, four magnet in series plus trims
    - Discarded because of complexity
  - Four power converter, one per magnet
    - Discarded because too many kA to bring around
  - This leaves one option …

CURRENTS AND POWERING

Powering layout 2 –proposed baseline [A. Ballarino, J. P. Burnet]



WHO DOES WHAT (TENTATIVE)



RISKS

- We have chosen the layout that maximizes performance
  - This (obviously) does not minimize risk
- Main concerns
  - Large fraction of coils rejected – not suitable for production
    - Producing and testing coils reduces the risk
  - The choice of a cored cable has never been validated
    - HQ02 will have it, we should have also HQ03
  - If all resources switched on QXF we stay two years without data
  - HQ started in 2009, in 5 years two magnet tested – too slow for QXF
    - Acceleration on HQ needed – its results relevant for QXF design
- How to minimize risks
  - Profit of synergies with 11 T
  - HQ03 should be planned and done asap
  - Manufacturing and test of long coils should be pursed (LHQ)

CONCLUSION

- We have a baseline from IP up to D1
- This is needed to estimate the heat load on correctors and D1 [June 2013]
  - So dimensioning cryogenics, iron holes, and possibly feeding back on aperture
    - Do we really need 160 mm D1 aperture ?
    - Do we need larger aperture for correctors ?
- We will review the layout at the end of the year
  - Feeding back more information on the heads and interconnections
- Layout up to Q4 needed by June
  - Work on D2 started [P. Wanderer, R. Gupta]
  - Work on Q4 ongoing – final choice coming soon [M. Segreti, J. M. Rifflet]