LAYOUT FOR INTERACTION REGIONS IN HI LUMI LHC

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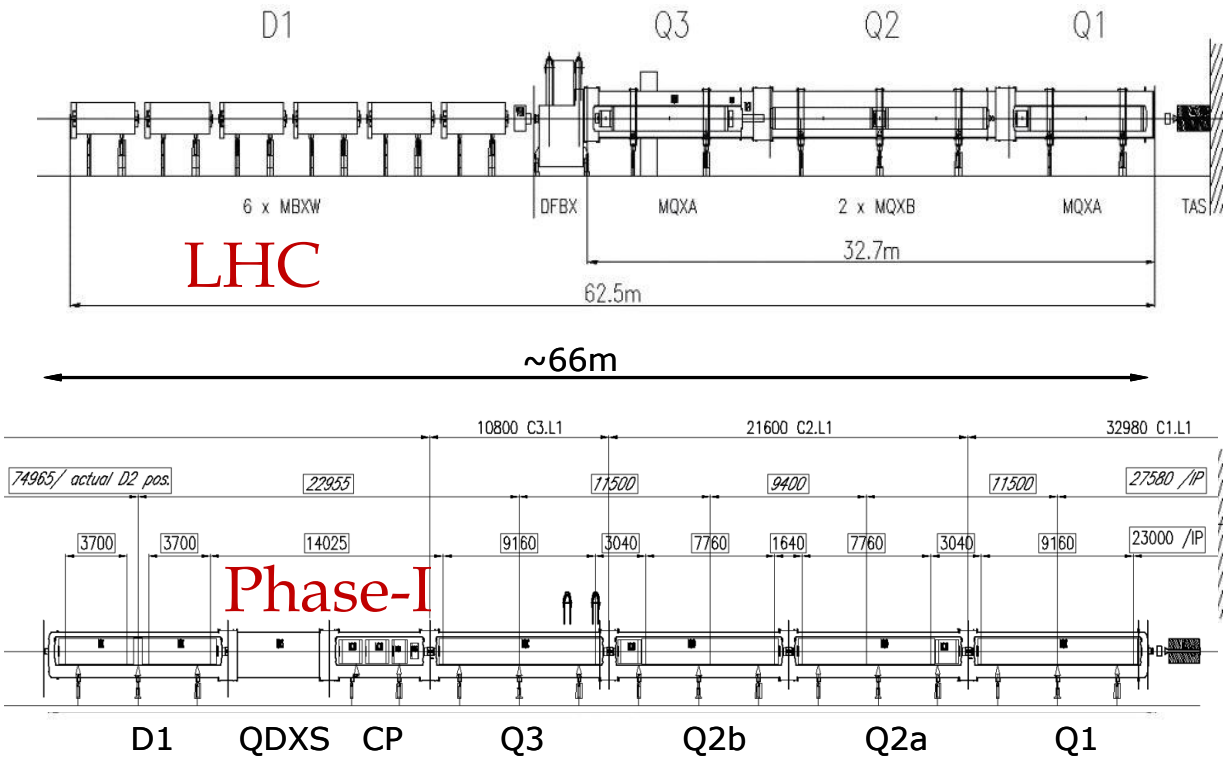
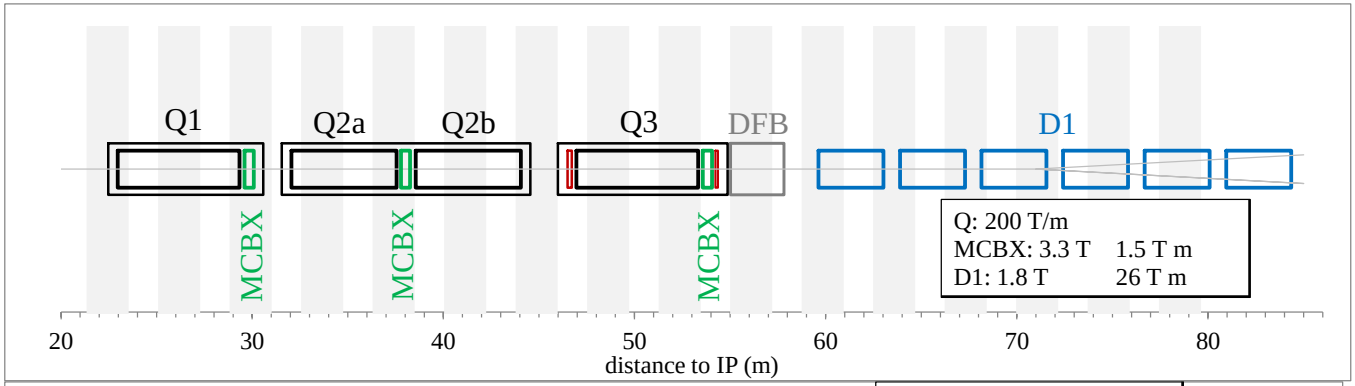
Acknowledgements: B. Dalena, M. Giovannozzi, R. De Maria, S. Fartoukh, B. Holzer, P. Fessia, M. Karppinen, A. Ballarino, J. P. Burnet, R. Ostojic, H. Prin, F. Toral, D. Ramos,

LAYOUTS

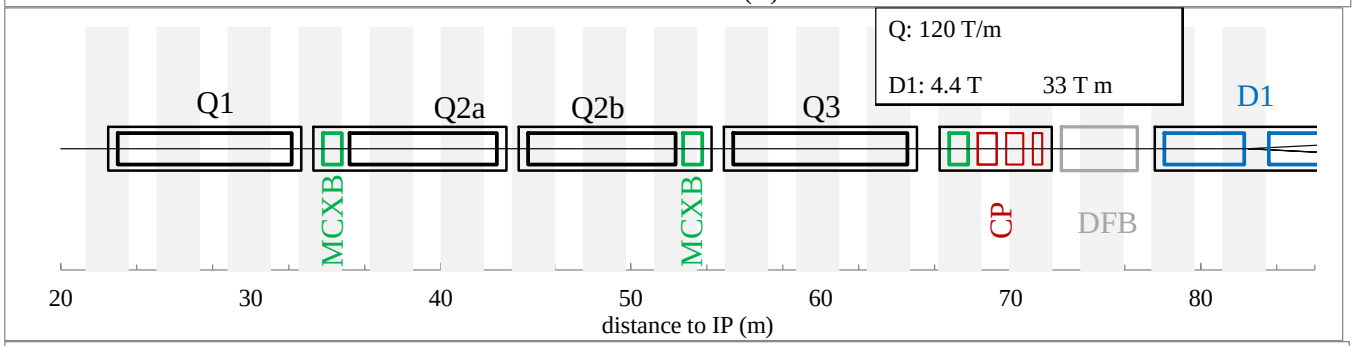


Layout of Phase I and LHC [R. Ostojic, S. Fartoukh, Chamonix 2010]

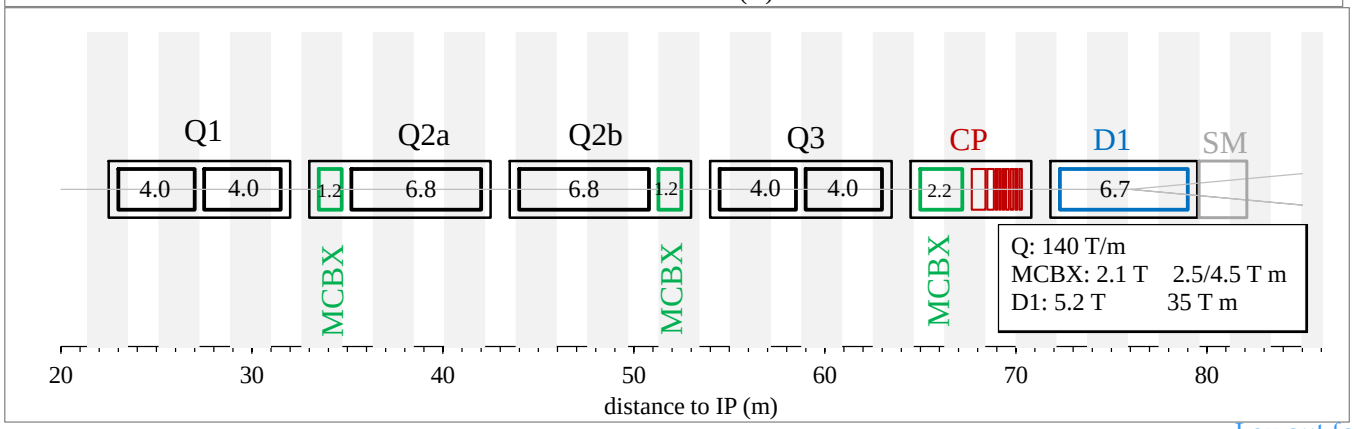
LAYOUTS



LHC

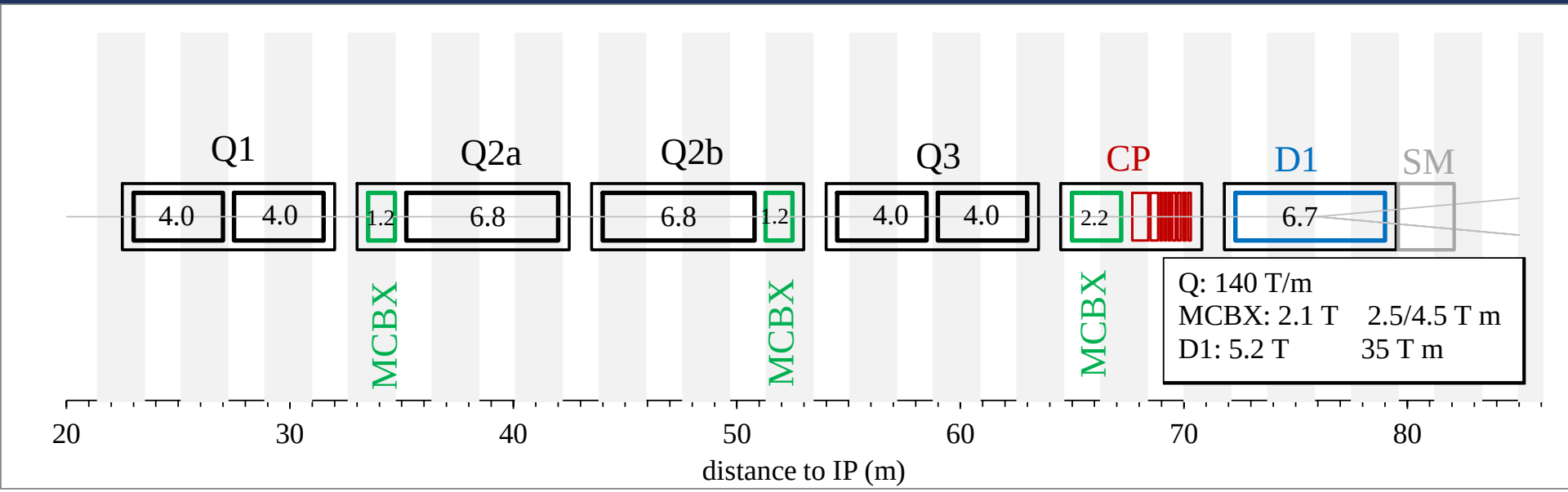


Phase I



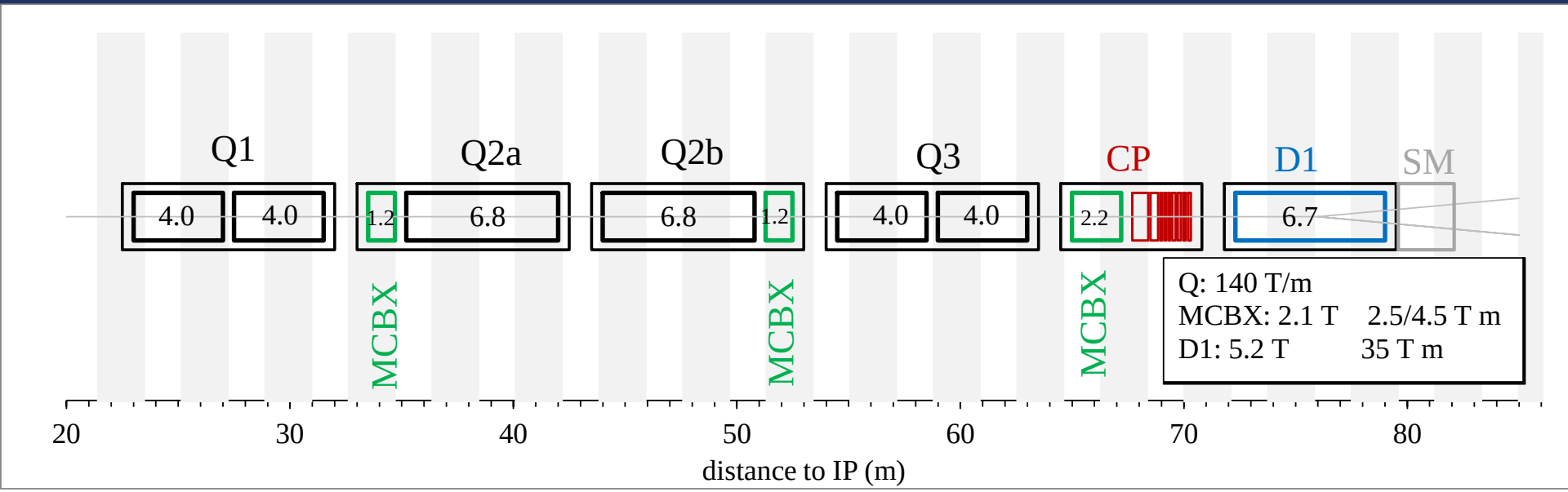
HL LHC

QUADRUPOLES



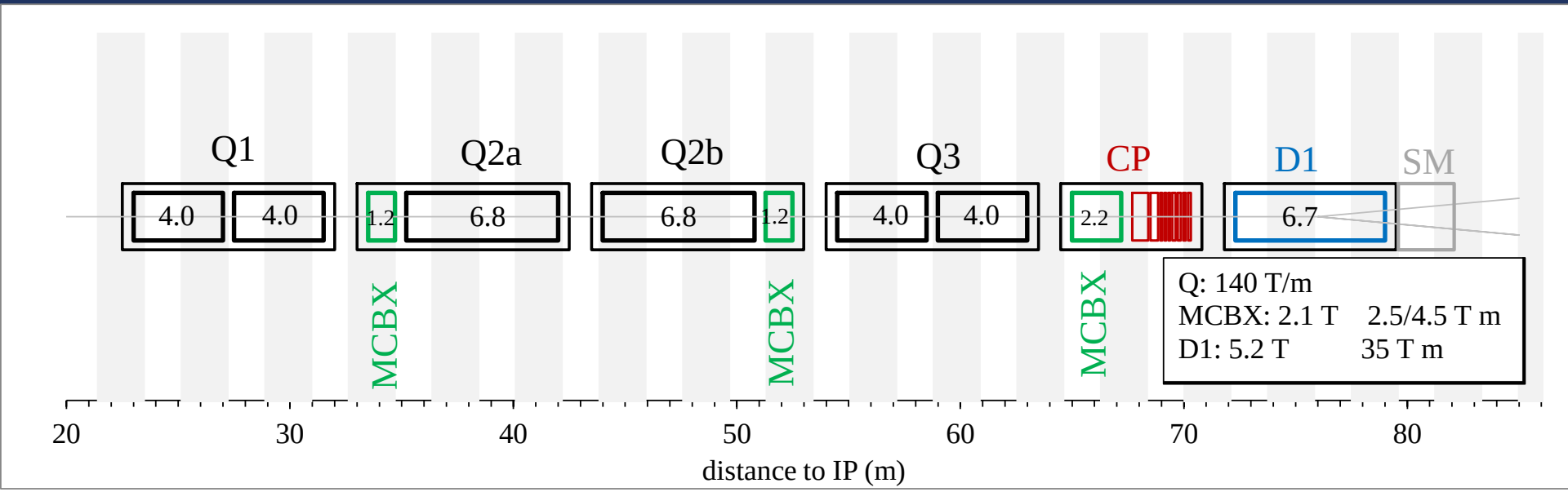
- Nothing new: 140 T/m, Q1 and Q3 split in two
  - 0.5 m between split cold masses (Q1 and Q3)
  - 0.5 m between end of magnetic length and end of the cryostat
- Cryostat choices:
  - Q2a and Q2b together makes a too long cryostat
  - We keep symmetry and modularity (two types only)

INTERCONNECTIONS

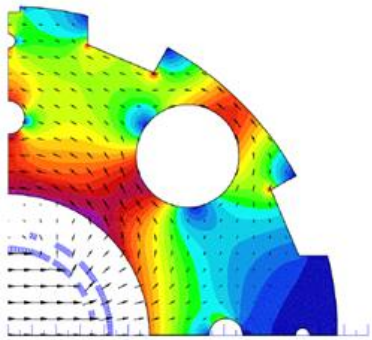


- 1.0 m between cryostats
  - 2.0 m between magnetic lengths
    - Space neeeded for Nb_3Sn Nb-Ti splices
  - All with the same to have standard IC
  - Possibly it could be reduced of 10-20 cm (in a second iteration)
    - Collision optics available since this week

ORBIT CORRECTORS

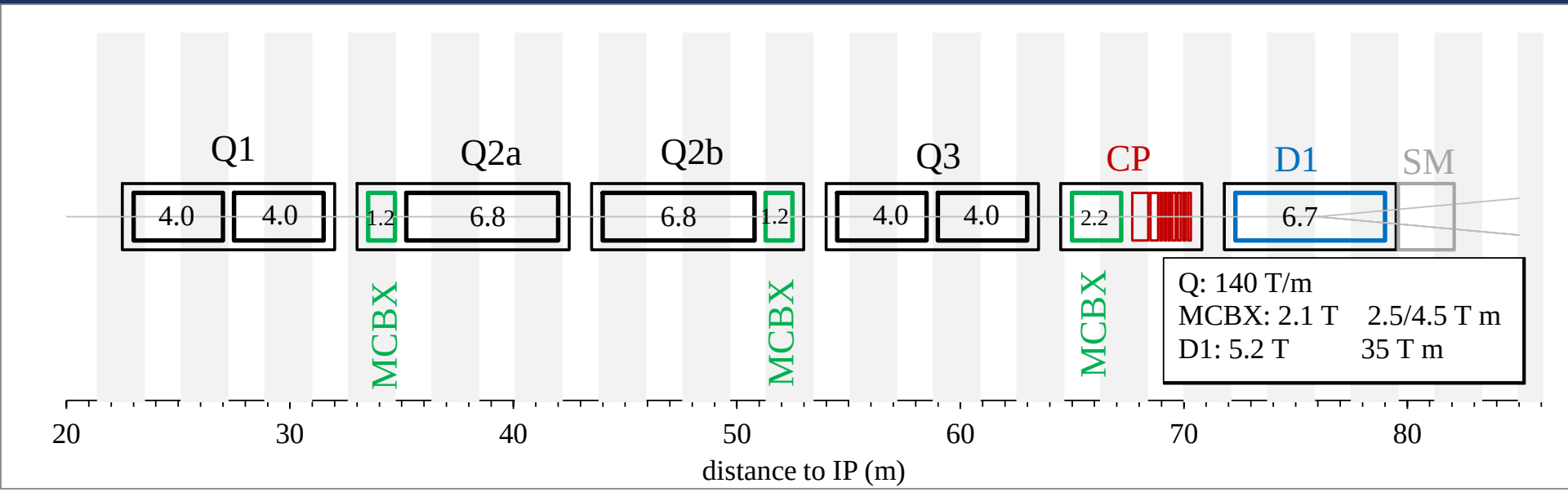


- Requirement is to have 2.5 T m around Q2, and 4.5 T m between Q3 and D1
  - Nested option to save space (4 m)
  - 2.1 T given by 50% margin with Mikko 4.6 mm width cable, one layer
    - So 1.2 m and 2.2 m respectively allocated
    - We could go to two layers, 4 T, saving 2 m but having 4 times torque

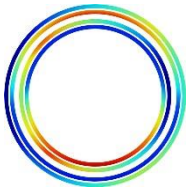


Proposal for nested MCBX (M. Karppinen)

ORBIT CORRECTORS

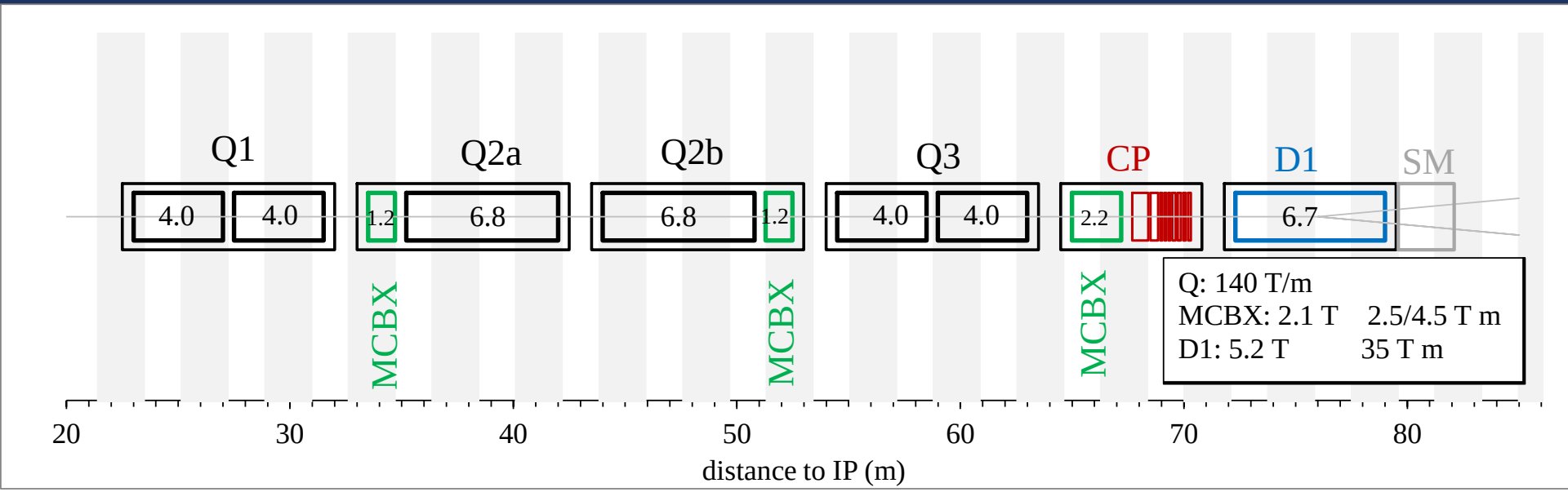


- Alternative options
  - We could go to Mikko design two layers, 4 T, saving 2 m but having 4 times torque
  - We could have a canted dipole – to be explored



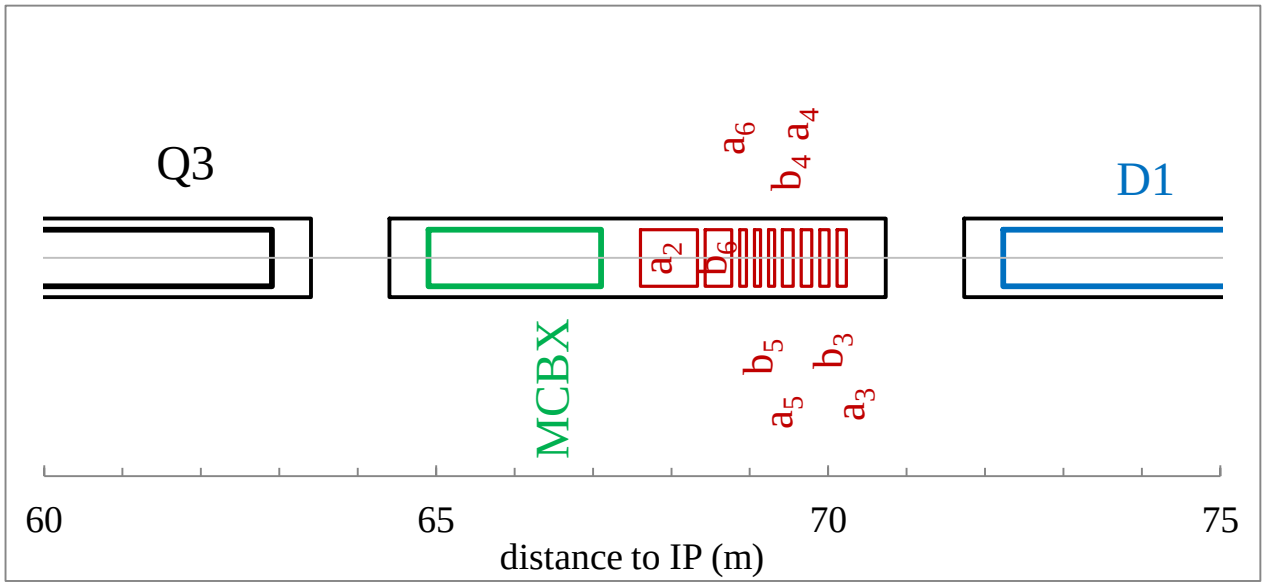
Proposal for canted dipole [J. V. Nutgeren]

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 b6 (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

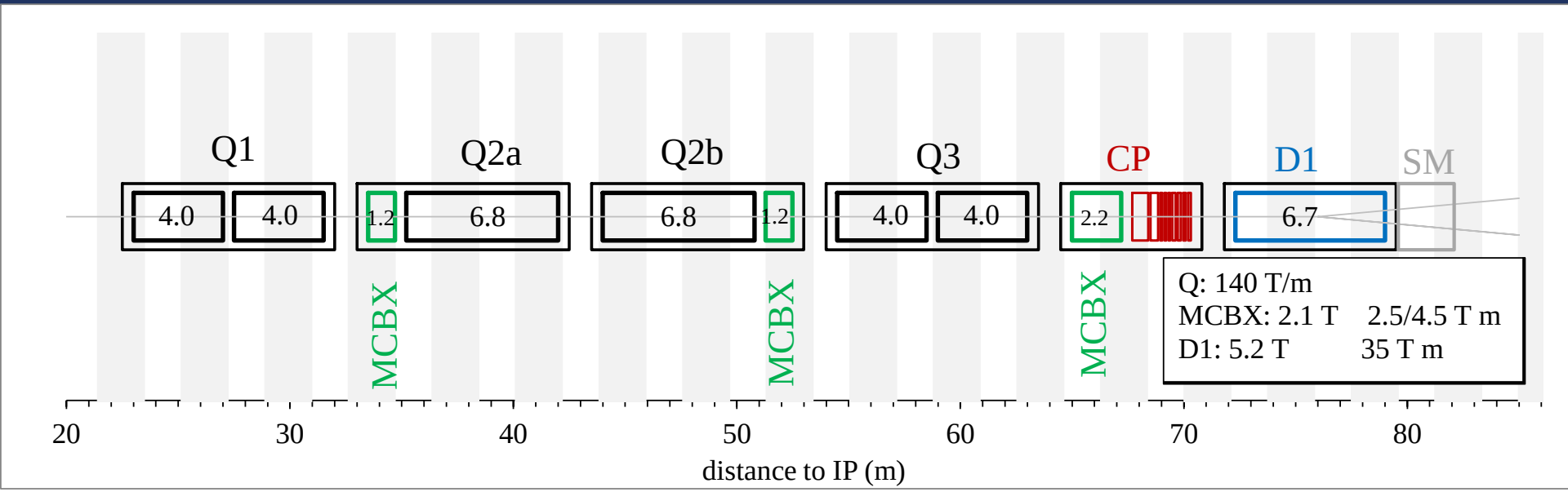
NONLINEAR CORRECTORS



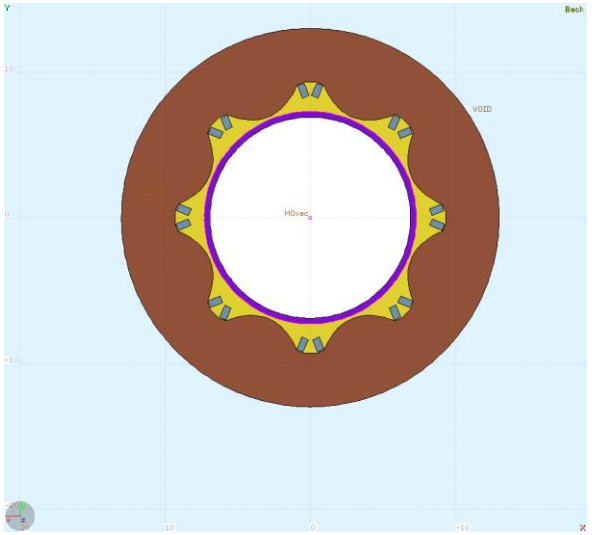
Name	Multipole	Coil length (m)	Force (T m)
MCQSX3	a_2	0.728	1.0000
MCTX3	b_6	0.339	0.0860
MCTSX3	a_6	0.087	0.0168
MCDX3	b_5	0.079	0.0254
MCDSX3	a_5	0.079	0.0254
MCOX3	b_4	0.137	0.0458
MCOSX3	a_4	0.137	0.0458
MCSX3	b_3	0.121	0.0625
MCSSX3	a_3	0.121	0.0625

- Requirements based on tracking studies [M. Giovannozzi et al]
- Detailed view of the corrector package

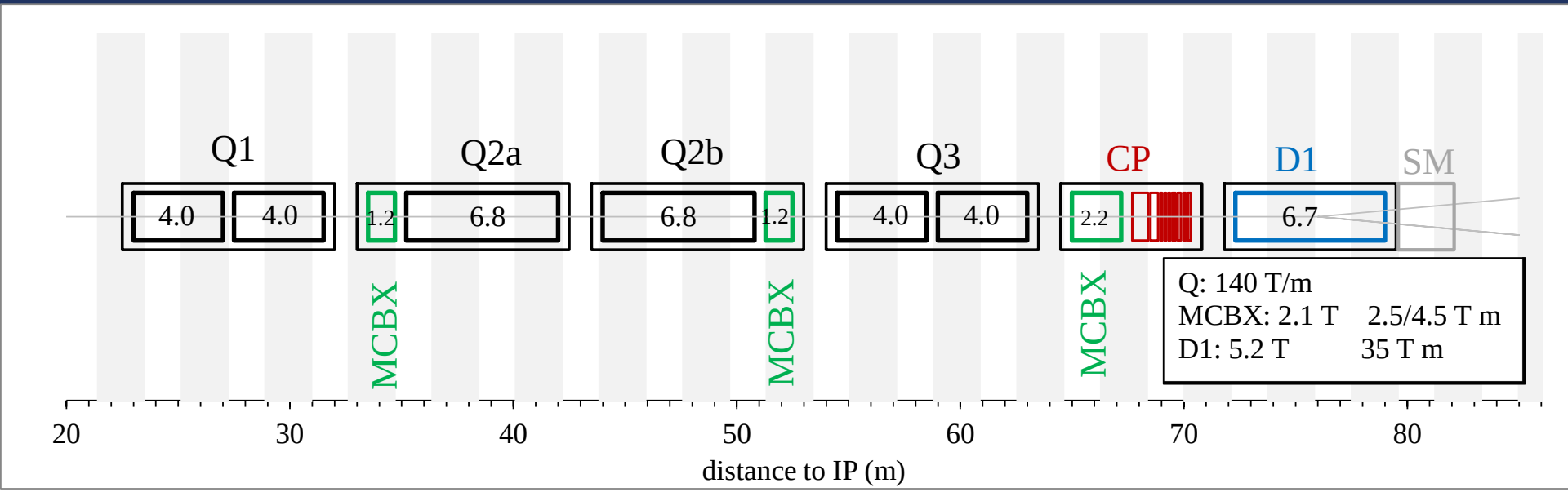
NON LINEAR CORRECTORS



- 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

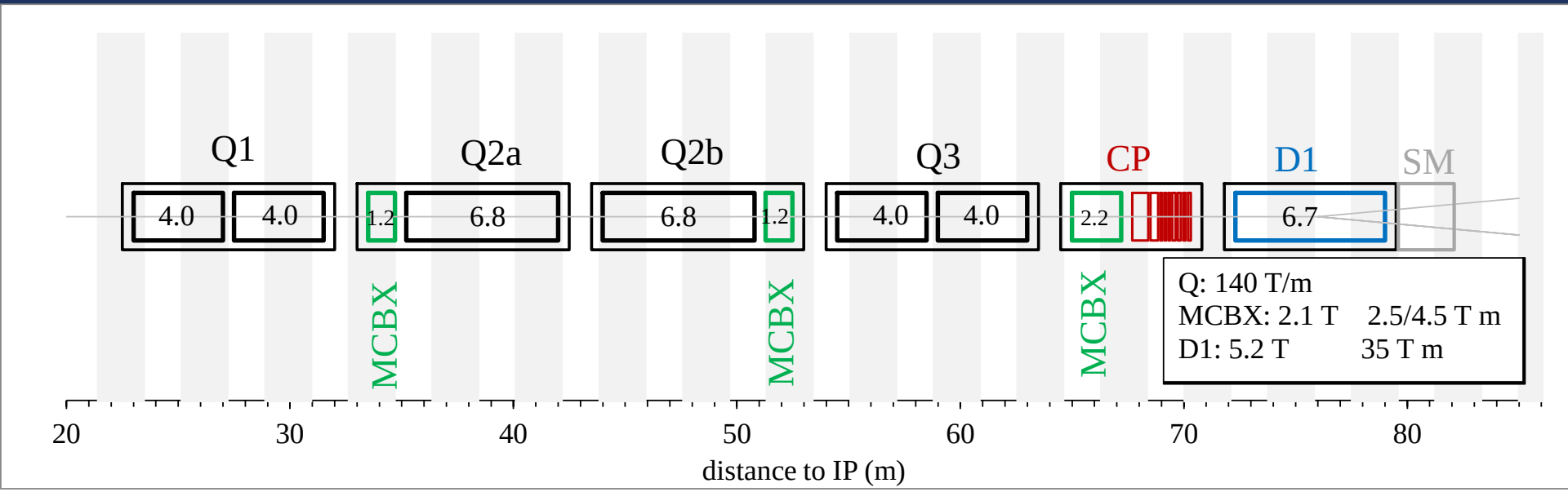


SEPARATION DIPOLE D1



- 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
  - Other 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

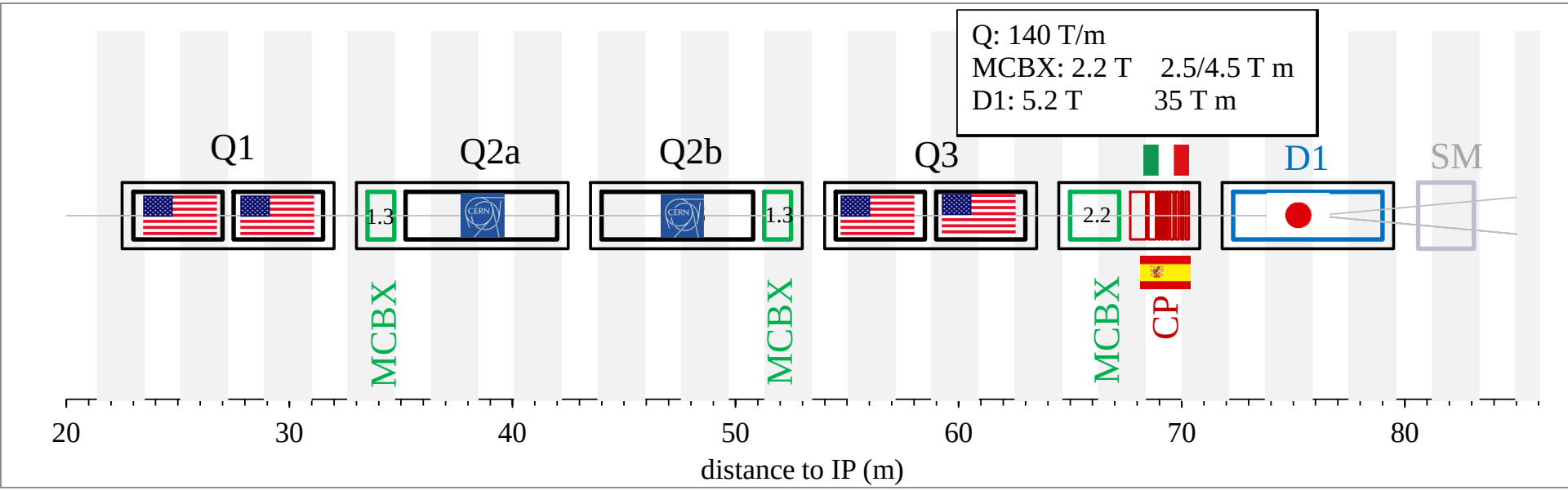
Currents

- 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
  - Triplet and orbit correctors: two HX, 80 mm, at 45 degrees
  - Corrector package: direct cooling or heat exchanger?
  - Dipole:
    - Two HX, different from the triplet (90 and 180 degrees)

      or
    - Direct cooling (but hotter coils)

WHO DOES WHAT (TENTATIVE)



AFTER Q4

- Requirements for main magnets

- Q5 with 70 mm aperture, and 770 T/m in IP1,5 and 6
  - Q4 provide 160 T/m at 4.5 K, 200 T/m at 1.9 K, 3.4 m magnetic length → 680 T/m
    - Four of them hot and available from point 1, 5, plus two spares?

- Q7 to be doubled in force (under evaluation for enhancing the crab cavity efficiency and optics flexibility [B. Dalena])
  - Today 200 T/m, 3.4-m-long; best solution would be to displace DFB and double it (4 additional MQM to be used)

- Both operations reduce our spares
  - Is this critical ? To be checked

CONCLUSION

- We have a baseline from IP up to D1
- This is needed to estimate the heat load on correctors and D1
  - So dimensioning cryogenics, iron holes, and possibly feeding back on aperture
    - Do we really need 160 mm D1 aperutre ?
    - 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,
- Full model up to Q4 needed by June

OPTICS REFERENCES

- S. Fartoukh, Chamonix 2010 (detailed triplet layout for Phase I including corrector, min. beta* of 25-30 cm, and first optics concept to compensate for the off-momentum beta-beatig in the LHC)
- S. Fartoukh, SLHCPR49 (2010), Chamonix 2011, and IPAC11 (removing the optics limitation with the ATS, description of scheme, corresponding optics with the Phase I triplet at 120 T/m, and first shopping list for new magnet aperture)
- R. De Maria, S . Fartoukh, SLHCPR55 and IPAC11 (introduction of the crab-cavity in the layout and first specifications)
- S. Fartoukh et al., Chamonix 2012, IPAC12 and ATS-Note 2013-04 MD (ATS optics developed for the nominal machine, and demonstration of the ATS in a series of MD down to 10 cm beta*)
- S. Fartoukh, R. De Maria, IPAC12 (ATS optics developed for other triplet layout 100 T/m and 150 T/m, i.e. 140 mm for NbTi and Nb3Sn, respectively, and review of the HL-LHC magnet shopping list)
- R. De Maria, S. Fartoukh, M. Giovannozzi, IPAC13 (IT corrector layout and specification)
- R. De Maria, S. Fartoukh et al., IPAC13 (Optics and layout retuned for the baseline 150mm-140 T/m HL-LHC triplet)
- B. Dalena et al., IPAC13 (Layout and optics variant by substancial modification of the matching section)