DR MAIN MAGNETS: DESIGN, COST ESTIMATE AND INFRASTRUCTURE REQUIREMENTS

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- Why an open midplane design
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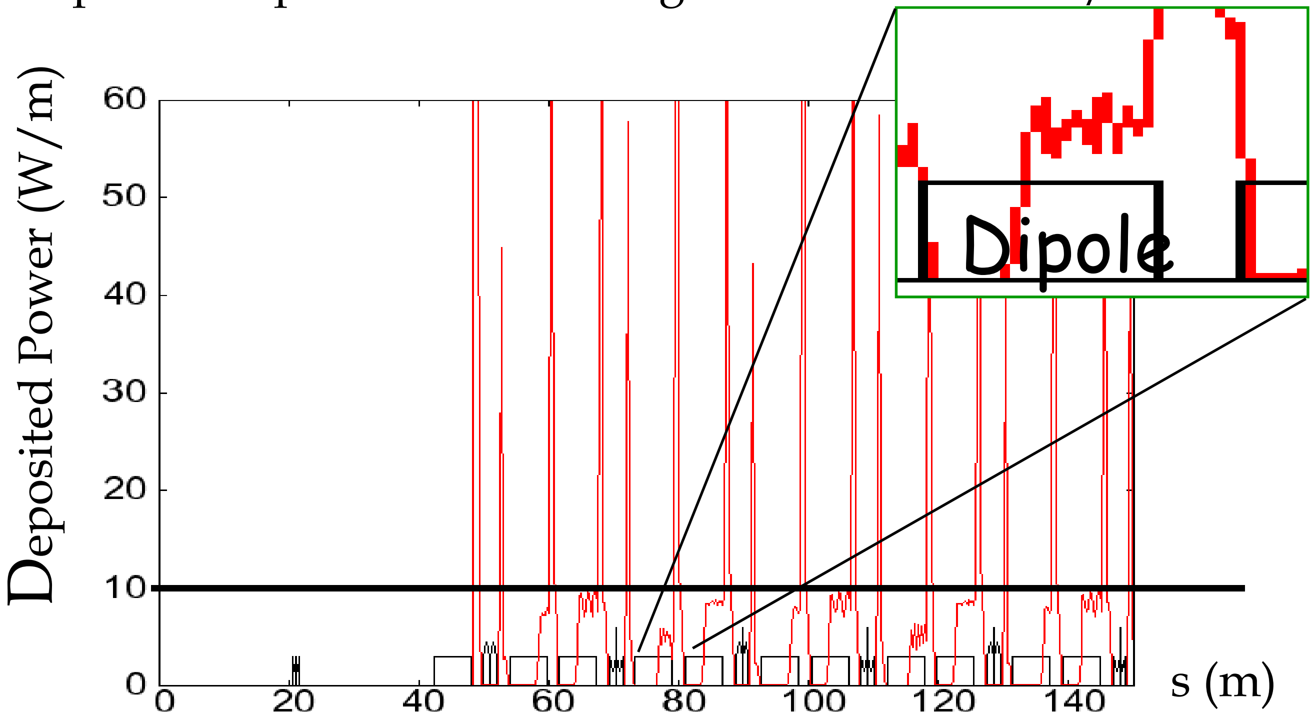
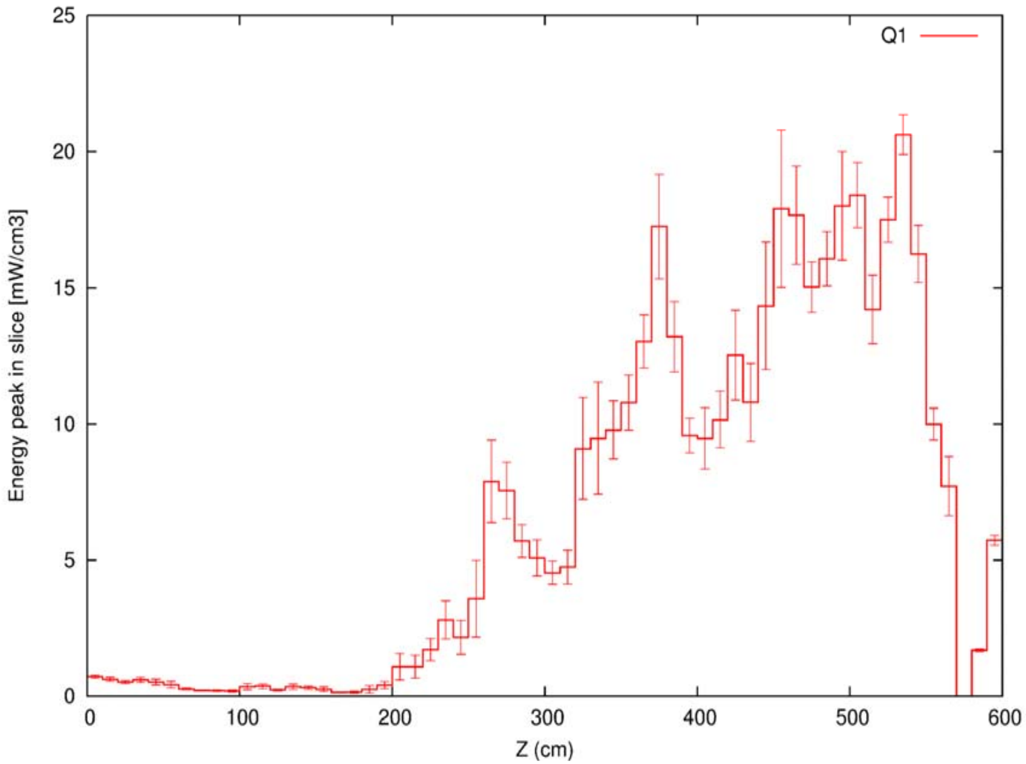
- Deposited power in the dipoles
  - Absorbers between the dipoles absorb most of the high energy particles
  - However, after each absorber there is a build up in the power deposition in each magnet
  - The power deposition in the magnet can reach 10 W/m



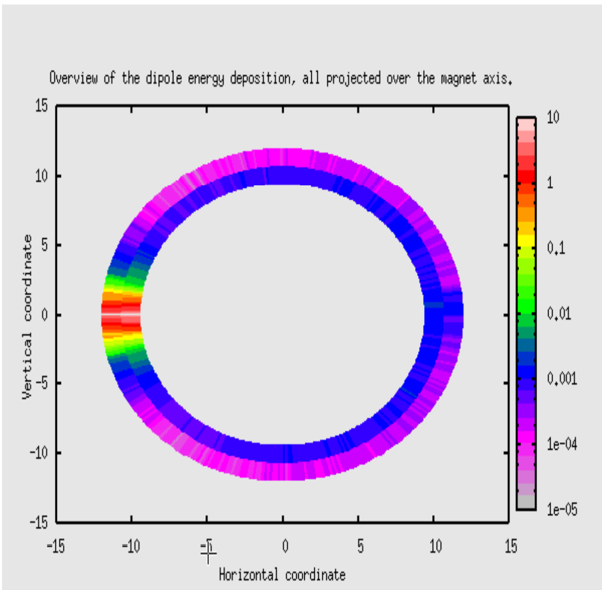
Introduction

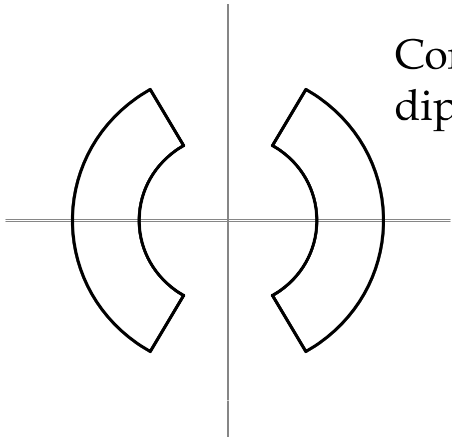
- Power deposition locally
  - Should not surpass 4 mW/cm3
  - The aim is to reduce the power deposition on the coil in the magnets by a factor 10, to have a safe marginal



- Energy deposition in the beta beam dipole
- The energy deposition in the beta beam dipole is concentrated in the midplane
- The superconducting coil in that area will experience a heat build up
- When the temperature surpass a critical value it will result in a quench in the magnet (quench = loosing superconducting property)

Midplane →

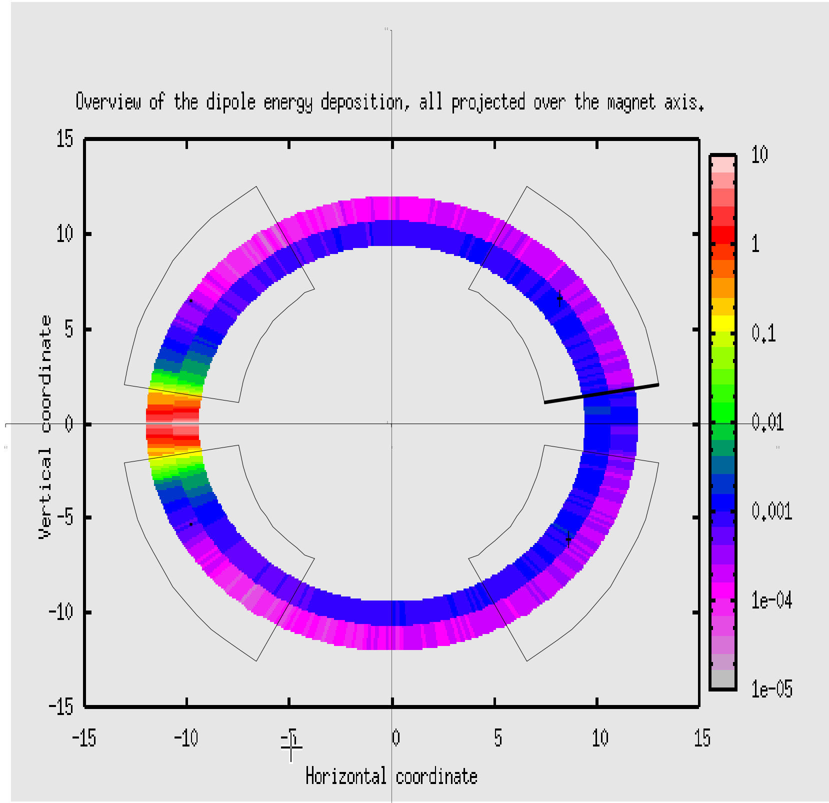


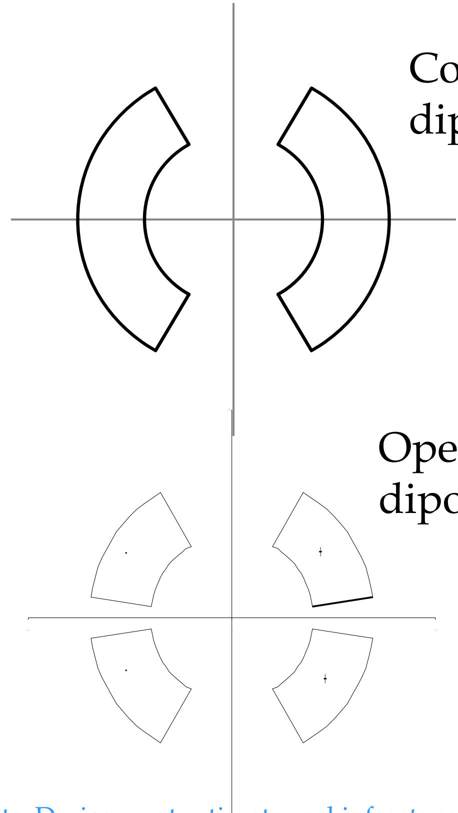


Conventional dipole

Why an open midplane design

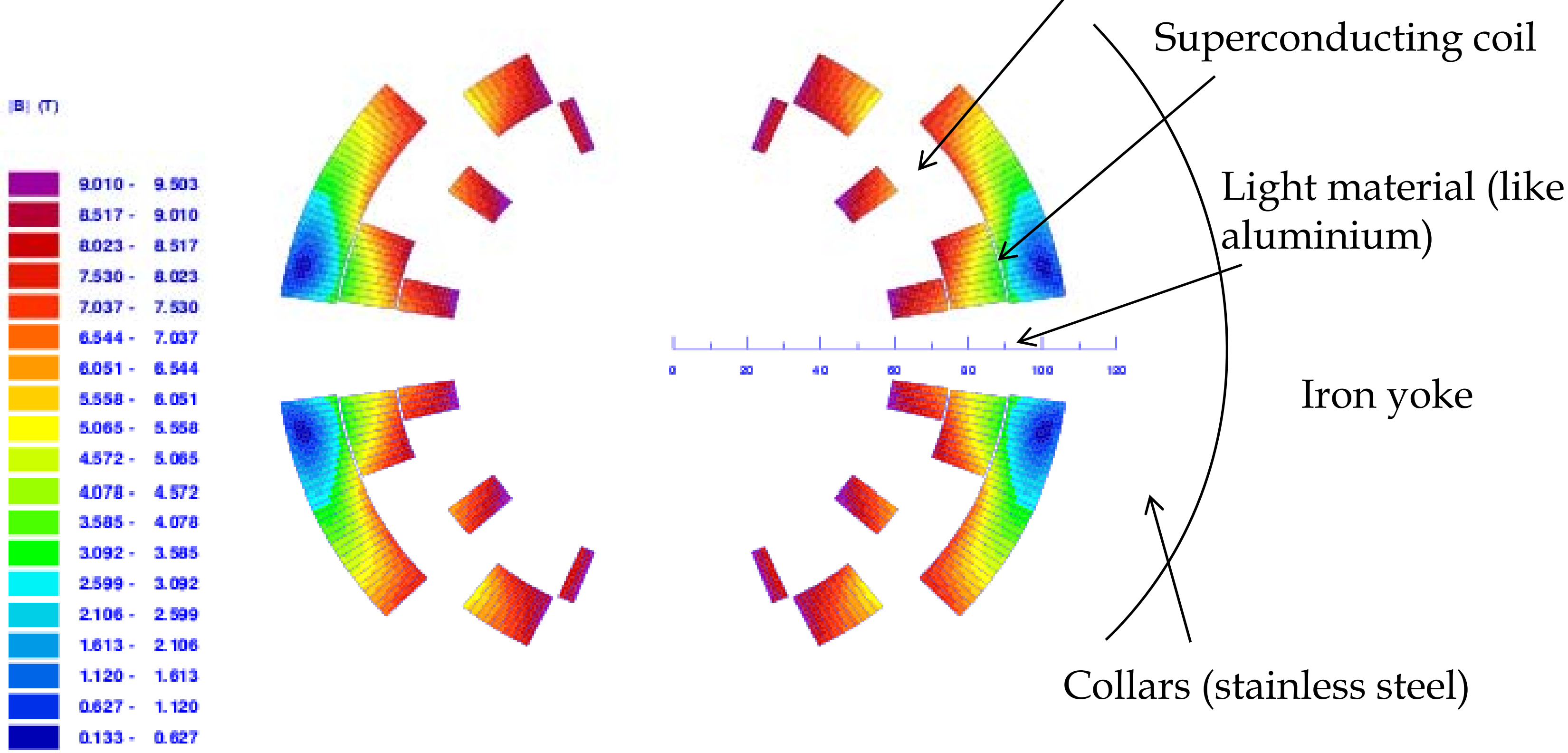
- Main idea: To avoid the heat deposition by opening up the magnet in the midplane – using an open midplane design
- The peak of the high energy particles will then pass in the gap and thereafter be trapped by absorbers aided by a heat transfer system



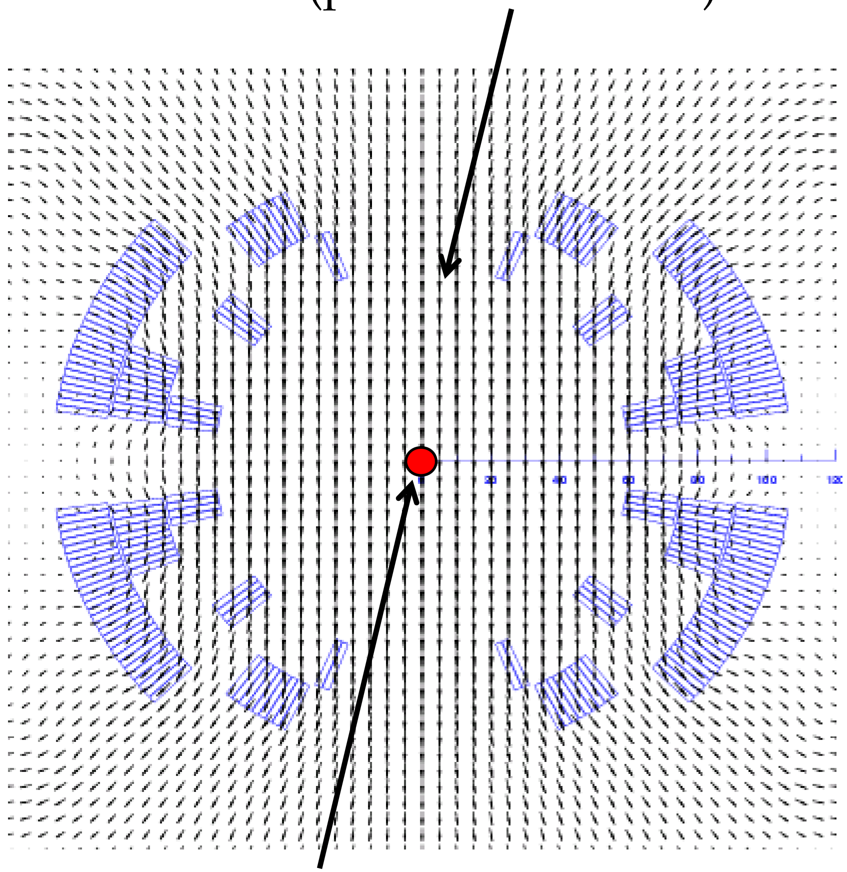


CROSS SECTION OF THE COIL LAYOUT

- Principal composition of the magnet

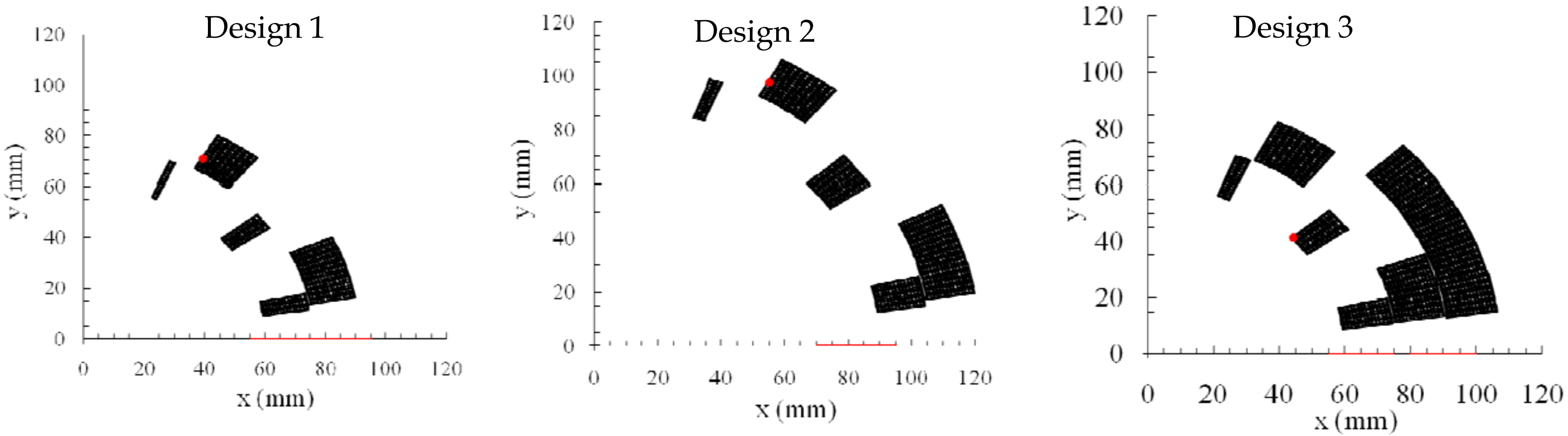


- Main important parameters for a dipole magnet
  - High field quality = highly homogenous field
    - Relatively easy to achieve, depends on the positioning of the coil sectors
    - In this case b_3 to b_{11} < 1, meaning as high field quality as the LHC MB
  - High field strength
    - In particular the central field, where the beam is located
    - The upper limit of this field is called the short sample field, symbol B_{ss}
    - Proportional to the amount of superconductors in the coil (up to a critical limit)



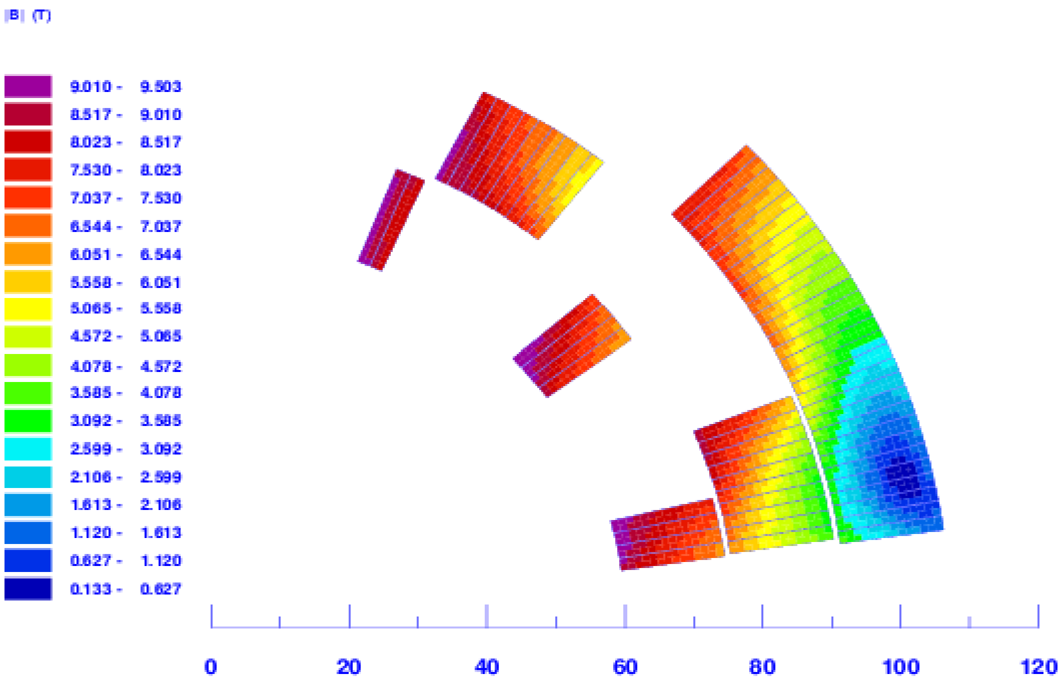
THREE DESIGNS

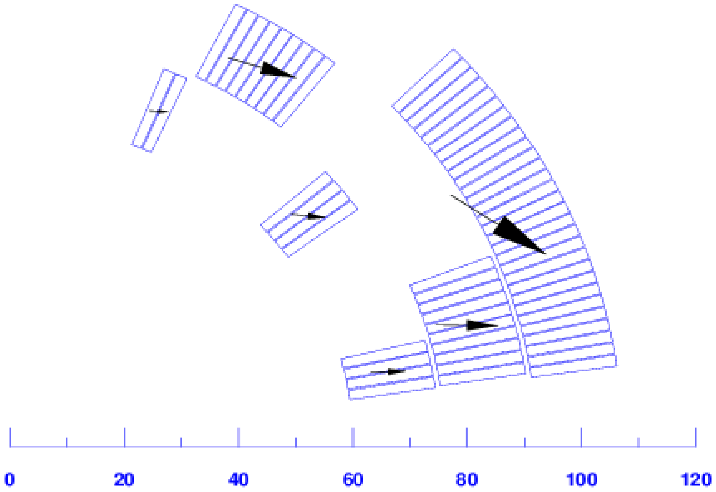
Design	1	2	3
Aperture radius (mm)	60	90	60
B_{ss} at 1.9 K (T)	6.5	6.8	8.7
Operational field at 1.9 K (T)	5.2	5.5	7.0
B_{ss} at 4.2 K (T)	4.9	5.3	6.7
Operational field at 4.2 K (T)	4.0	4.2	5.4
Gap in midplane (mm)	8.9	12.5	8.7
Yoke (mm)	180	270	240



Lorenz forces and magnetic field for design 3

- Magnetic field map
- Lorenz forces

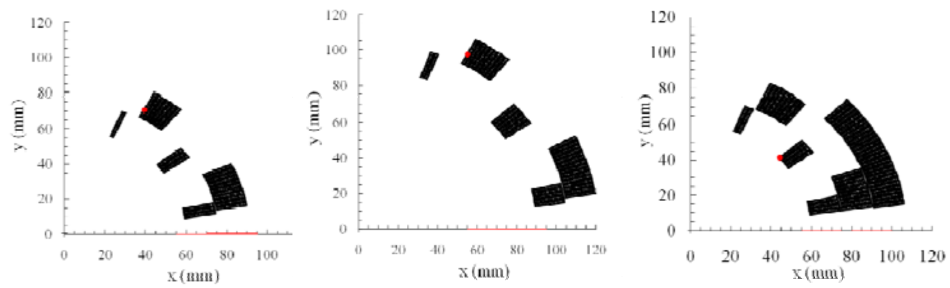




Forces on the sectors (kN/m)			
sector	X	Y	Radial
1	413	17	408
2	407	-39	289
3	225	-16	72
4	738	-11	707
5	803	-248	215
6	1137	-758	695

COST ESTIMATION

- For magnet fabrication and assembling, calculated for a 13 m long dipole



Design 1 Design 2 Design 3

Cost (MCHF per unit)	Design 1	Design 2	Design 3
Magnet (material + fabrication)	0.71	0.76	0.82
Cryostat	0.1	0.1	0.1
Cryoplants at 1.9 K	0.3	0.3	0.3
Cryoplants at 4.5 K	0.2	0.2	0.2
Total at 4.5 K	1.01	1.06	1.12
Total at 1.9 K	1.11	1.16	1.22

- Two choices, either operating at 1.9 K or at 4.2 K
- 1.9 K require a more expensive cryo system, but allows a higher short sample field (and therefore operational) in the magnets
- If the working temperature 4.2 K is chosen, then these designs are not enough to meet the requirements of an operational field strength of 6 T
  - Then at least one additional layer has to be added to Design 3, resulting in an even bigger coil
  - Will result in a more expensive magnet and might be at the limit of what is possible at 4.2 K

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Operational field at 4.2 K (T)	4.0	4.2	5.4

CONCLUSIONS

- By opening up the midplane, the heat deposition on the critical area of the magnet can be decreased by at least a factor 10

- An open midplane design is feasible, both regarding field quality and the desired field strength of 6 T, when operating at 1.9 K.

- At 4.2 K it is harder to reach 6 T, and Design 3 has to be modified with additional layers.

- Further R & D are required, to find out the most cost effective solution