FCC-hh 16 T, 1.9 K

INFN Team

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Why 1.9 K ?

- At 4.5 K the volume of conductor is quite large , cables have extreme dimensions, ratio Cu/Sc is 1/1, no margin left
- At 1.9 K is feasible owing to the large increase of critical current respect to 4.5 K

B (T)	Jc (A/mm2) 4.5 K	Jc (A/mm2) 1.9 K	ratio (1.9/4.5)
14	2031	3005	1.48
16	1251	2048	1.64
18	695	1326	1.91

Based on the formula given in EuroCircCol-P2-WP5-04-09-2015

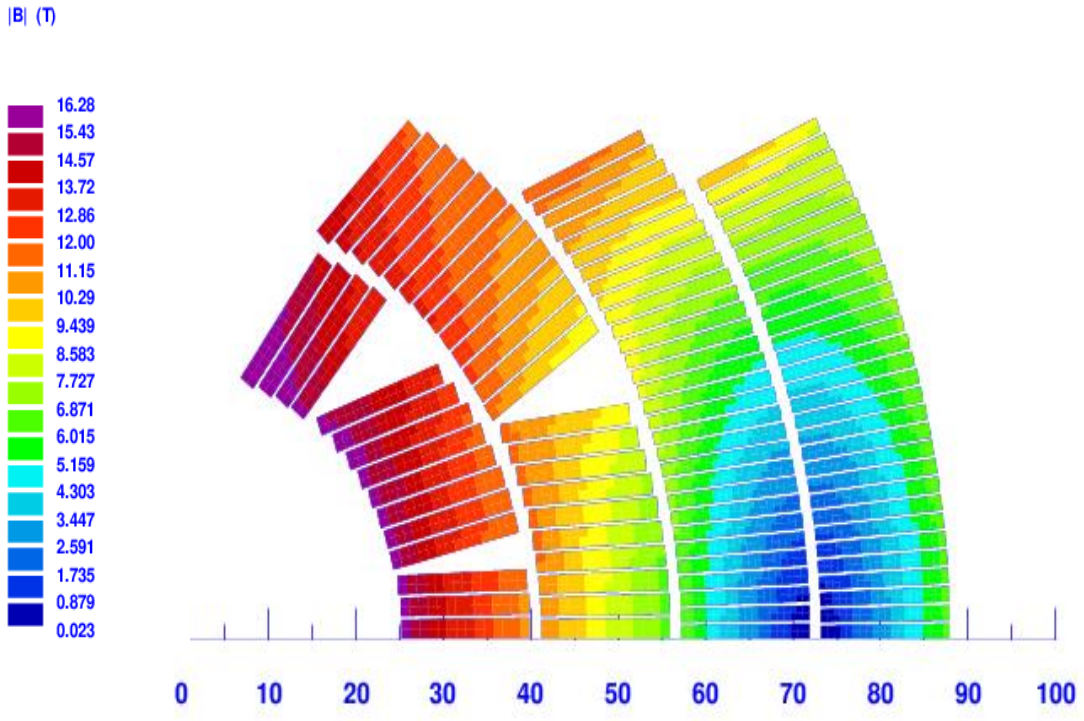
A conceptual design at 1.9 K

- Based on a design presented by Zlobin (FERMILAB) at the FCC week 2015
- Assumed peak field of 18 T on conductor giving 17.6 T bore field (10% margin)
- Assumed 4 layers i.e 2 double pancakes
- Two cables

Cables	Strands/ϕ	Cu/nonCu	Width (mm)	Mid thickness (mm)
Inner	28 / 1.0mm	1/1	14.7	1.80
Outer	40 / 0.7 mm	1.5/1	14.7	1.25

- Insulation 0.2 mm /face
- Iron yoke far apart (from 120 to 250 mm)

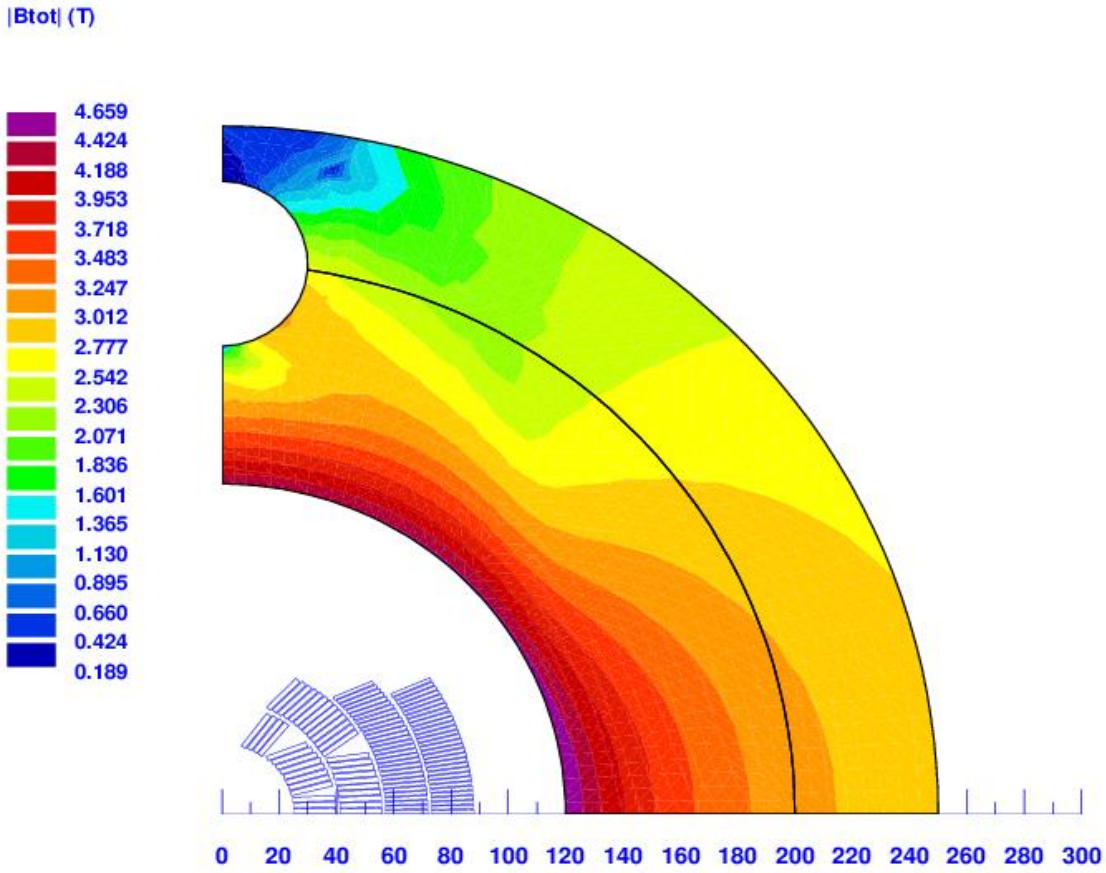
The layout



I= 12.0 kA Bo = 16 T (I=13.4 kA for Bo=17.6 T)

Layer 1-2 15+23 turns
Layer 3-4 31+31 turns
Total 100 turns Total width of the layers 60.4 mm

Field in the iron at Bo=16 T

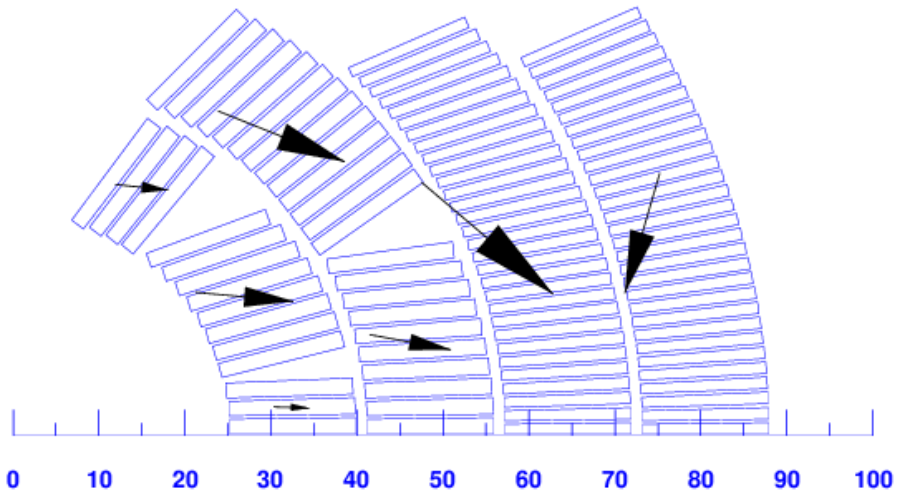


Strong saturation

Field on the iron midplane By= 4.5-3.0 T

Fringing field (x=300 mm,y=0) By= 0.5 T

Forces at Bo=16 T



Fx = 6.5 MN/m

Fy = -4.1 MN/m

Field quality

Not pursued, pending many unknows on cables dimensions, insulation thickness, position iron yoke (i.e collar thickness)

I = 12.0 kA

MAIN FIELD (T) 15.9167

NORMAL RELATIVE MULTIPOLES (1.D-4):

b 1:	10000.00000	b 2:	0.00000	b 3:	-4.82026
b 4:	0.00000	b 5:	-0.54876	b 6:	0.00000
b 7:	0.43971	b 8:	0.00000	b 9:	-1.86855
b10:	0.00000	b11:	1.60804	b12:	0.00000

Inductance 20 mH/m

Stored energy 1.28 MJ/m

Conclusion

- A 16 T dipole at 4.5 K with a 10% margin has been envisaged at the limit of feasibility (with a low Cu/Sc ratio 1/1 for the outer layers)
- A conceptual design of a 16 T dipole at 1.9 K with a 10% margin is proposed
- At 1.9 K, a further margin increase of 5% look feasible possibly, with the same volume of superconductor since in this design the outer cable has more strands (40) than needed (30)
- A reduction of the insulation thickness from 0.2 mm to 0.15-0.125 mm could give a 2-3% margin increase owing to the better filling factor of the conductors in the layers
- A comparison of the dipole design at 4.5 K and 1.9 K is very useful, unless the temperature of 4.5 K is mandatory (why?)