

Preliminary Magnetic Analysis of the CCT Magnet for HL-LHC

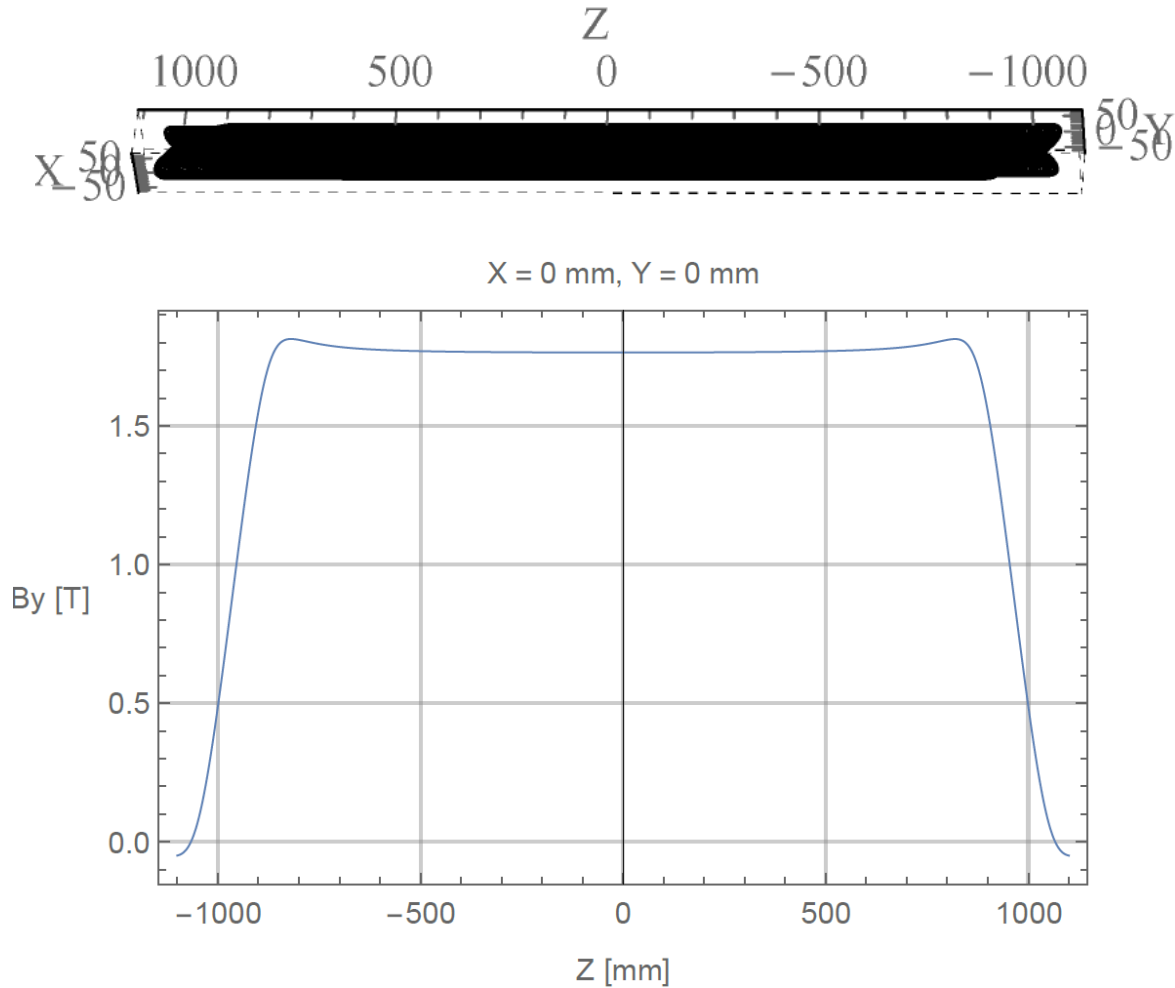
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2017.5

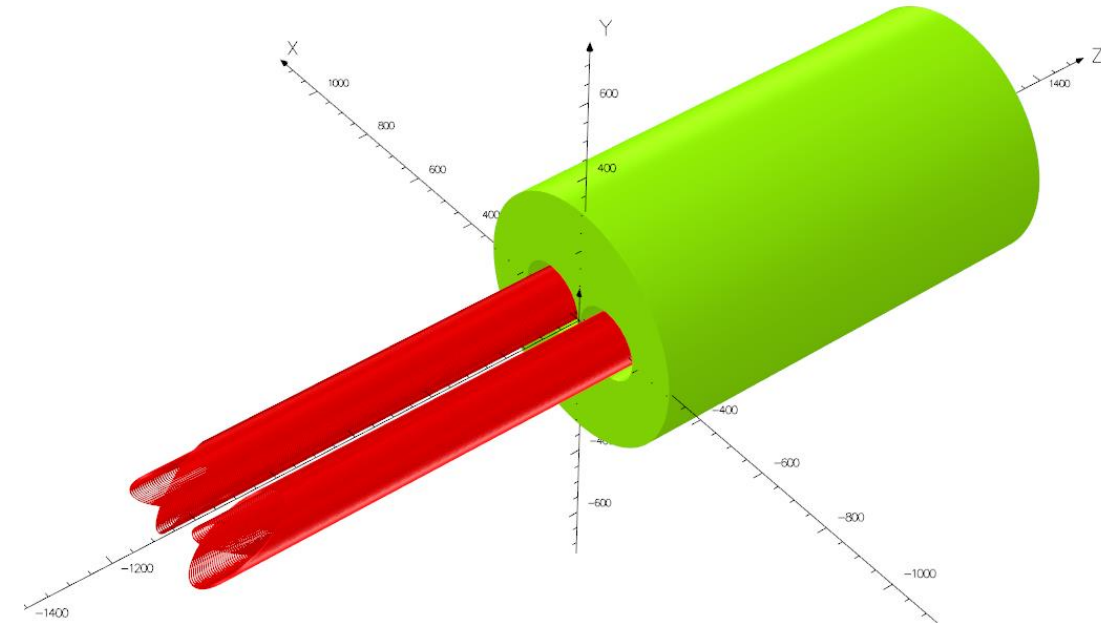
2m Model without iron



Single coil	value
Bore field / T	1.76
Current / A	435
Layers	5+5
CCT angle / °	30
Magnetic length / m	1.92
Turns per layer	371
Pitch / mm	5.2
Aperture diameter /mm	105

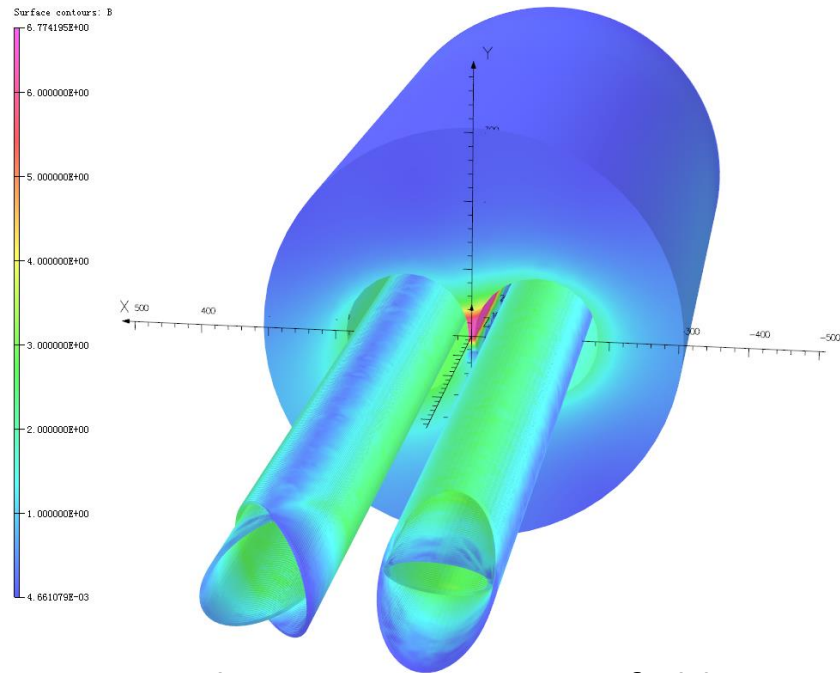
Using the RADIA single line current model, the basic electromagnetic parameters of coils can be determined quickly. With the Opera electromagnetic analysis software, We completed the electromagnetic design of magnet. It not only saves the design time, but also verifies the design of the rationality and consistency.

2m Model with iron

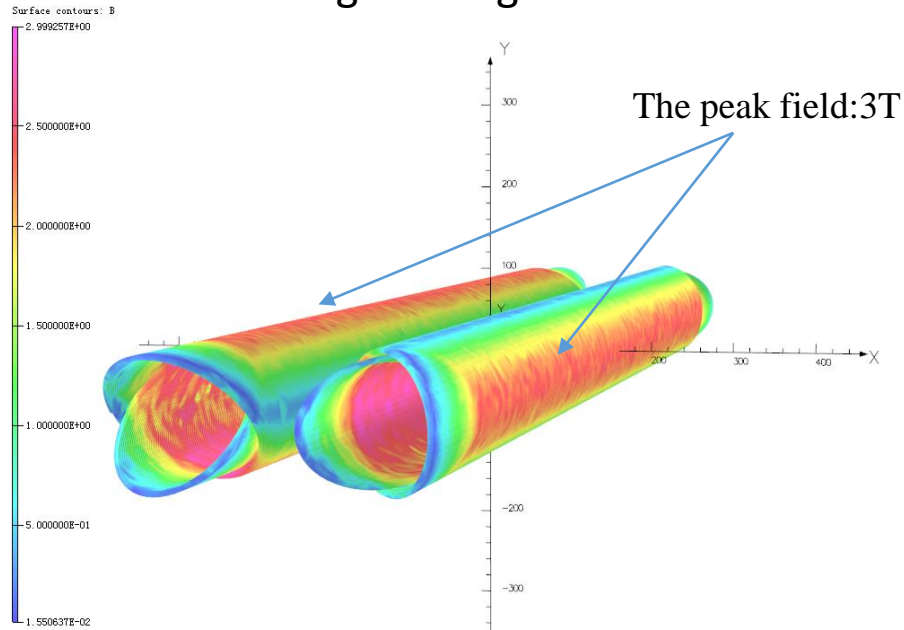
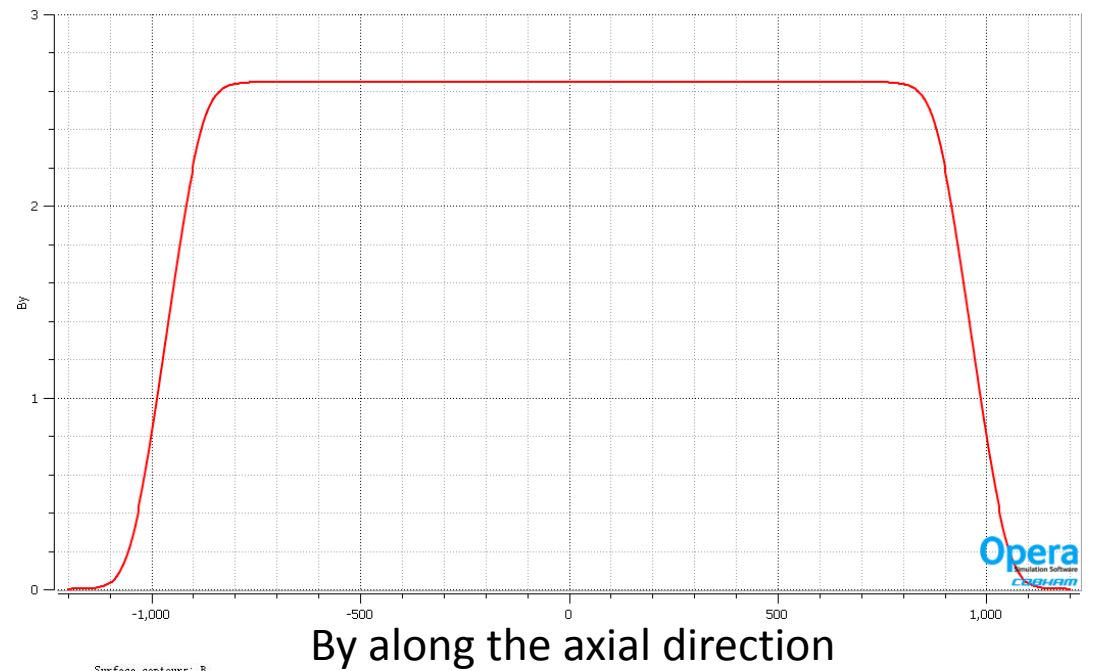


Magnet model in 3D with Opera

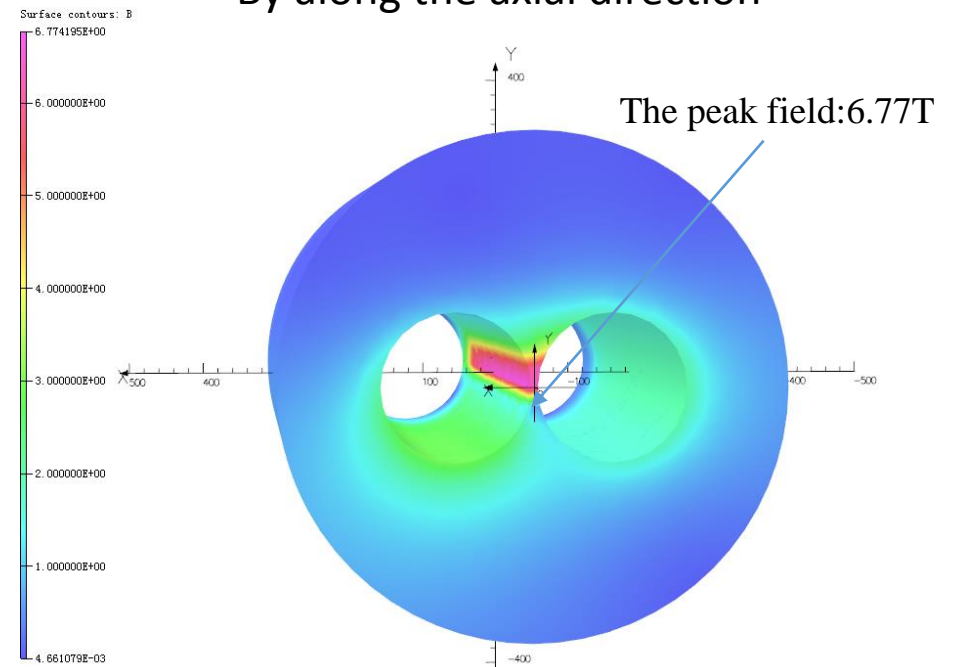
D2 orbit corrector magnet electromagnetic parameter	
Bore field / T	2.65
Current / A	435
Layers	5+5
CCT angle / °	30
Magnetic length / m	1.93
Turns per layer	371
Integrated field / Tm	5.1
Peak field / T	3
Io/Ic	55%
Slot size in former	2 mm*5 mm,0.6 mm for rib
Inside and outside the former/ mm	The first layer: 105 /120 ; The second layer:120.4 /134.4
Dia of wire / mm	0.825
SC wire length / km	7.2



The magnet magnetic field



The coil magnetic field



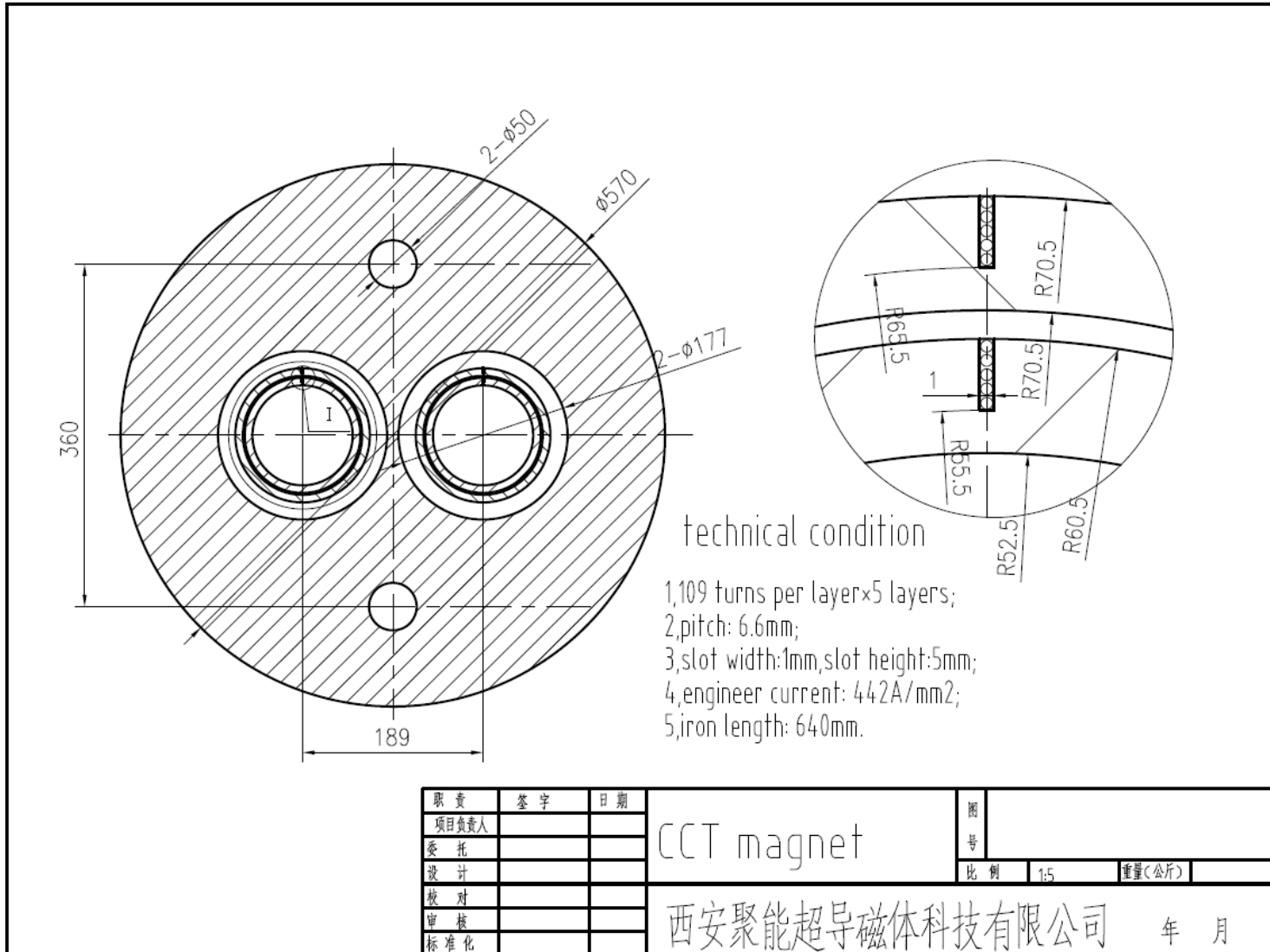
The iron magnetic field

2m Model with iron

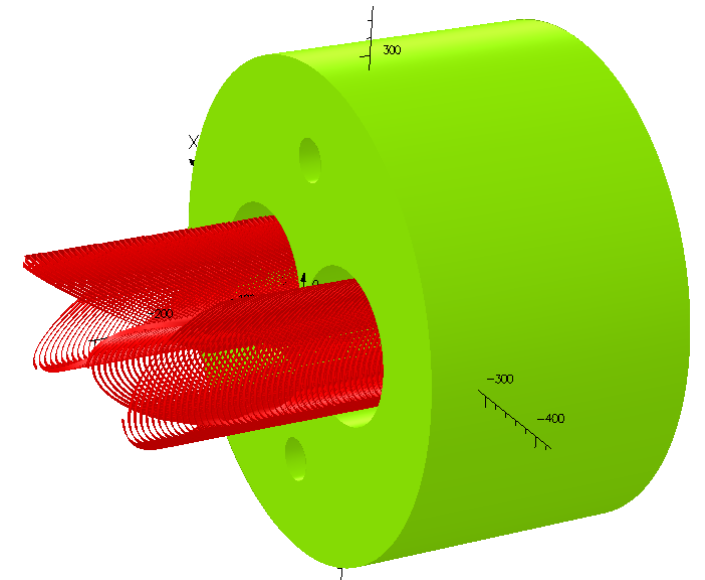
Computed harmonics at the mid-plane at Rref = 35mm (left coil)

Multipole order	Skew	Normal	Multipole Units	
			an	bn
0	0.0	26480.6814	10000	10000
1	-3.0507	-2.4828	-1.1520	-0.9376
2	-2.4808	-2.2620	-0.9368	-0.8542
3	-2.1274	-0.1946	-0.8034	-0.0735
4	-1.0175	-0.3202	-0.4182	-0.1209
5	0.0017	0.0901	0.0006	0.0340
6	0.4450	0.0019	0.1680	0.0007
7	0.9250	0.3325	0.3493	0.1556
8	0.5907	0.0406	0.2831	0.0153
9	0.7253	0.3242	0.2739	0.1224

0.5m Model

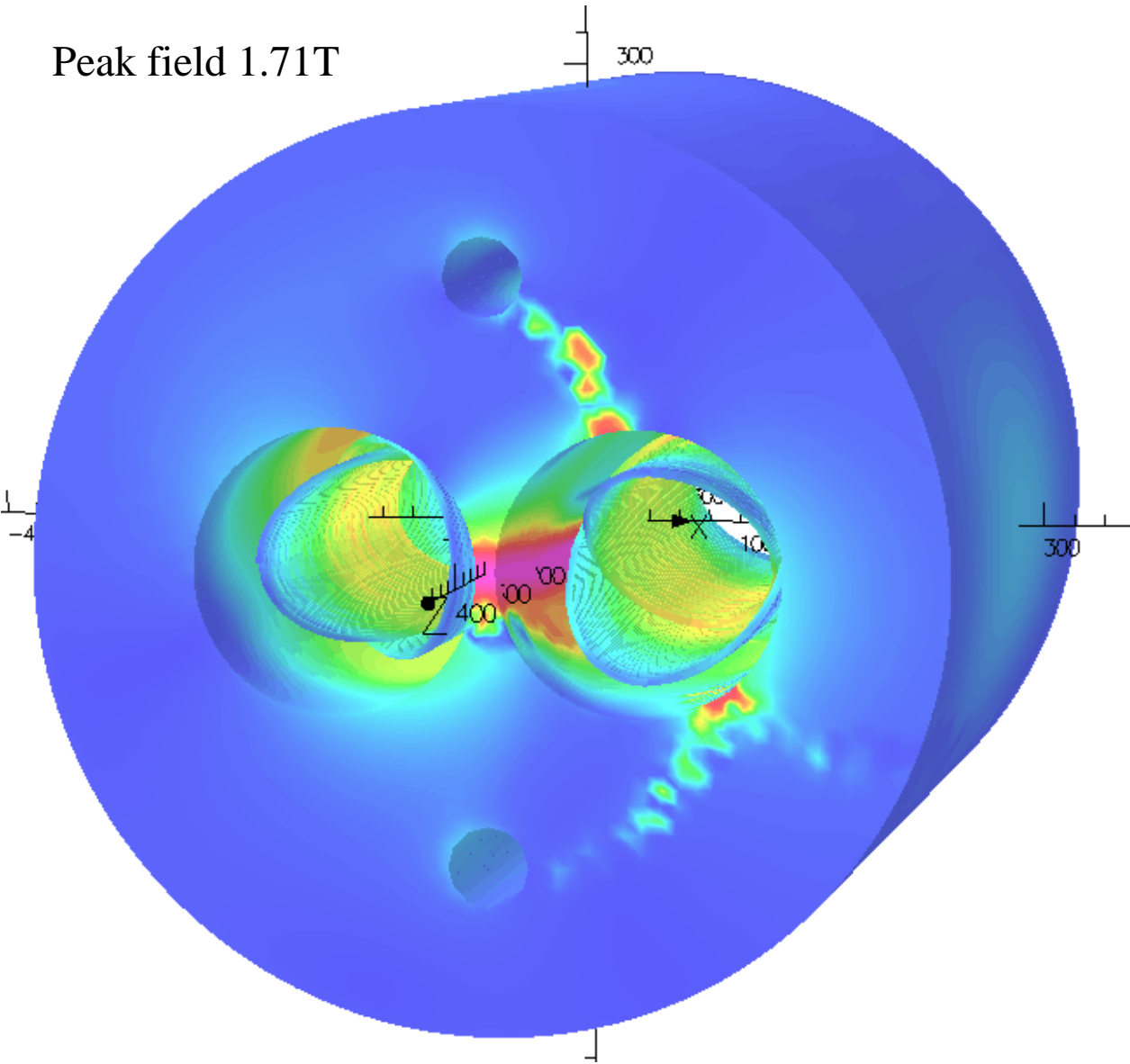


Iop	422 A
Wire diameter	Φ0.825 mm (with 0.05mm glass impregnated insulation)
Engineer current density	422A/mm ²
Pitch	6.6mm
Slot width	1mm
Slot height	5mm
NO. of turns per layer	109

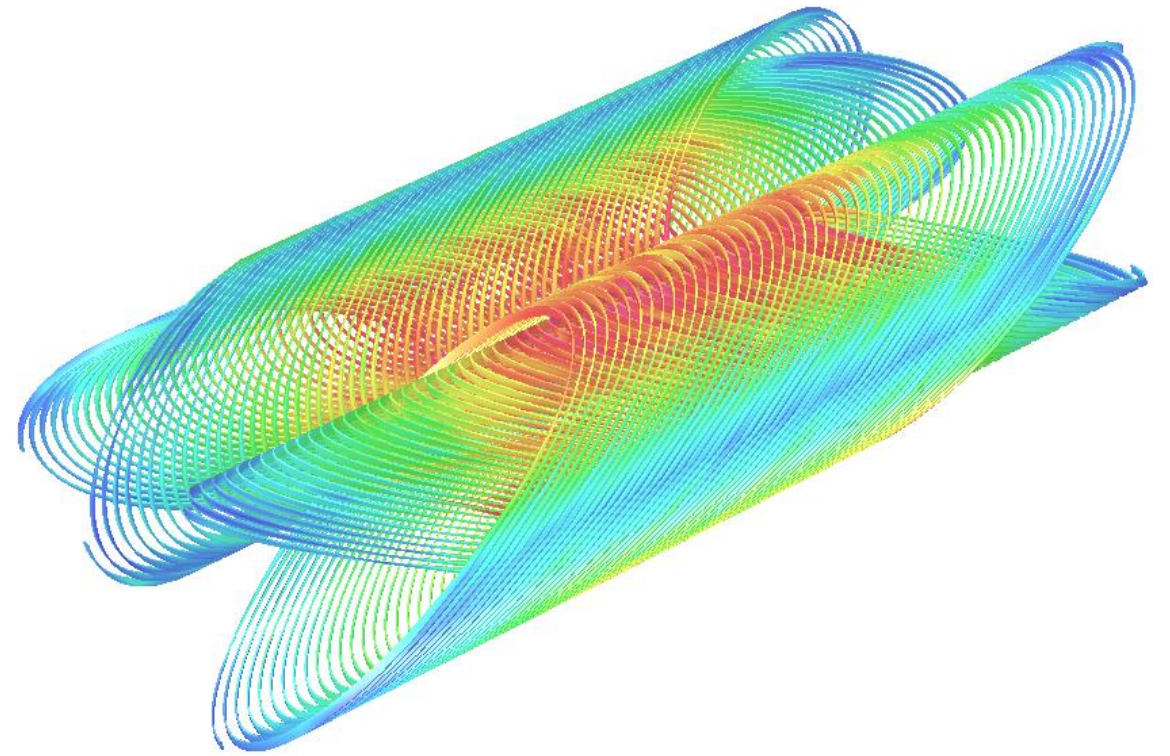


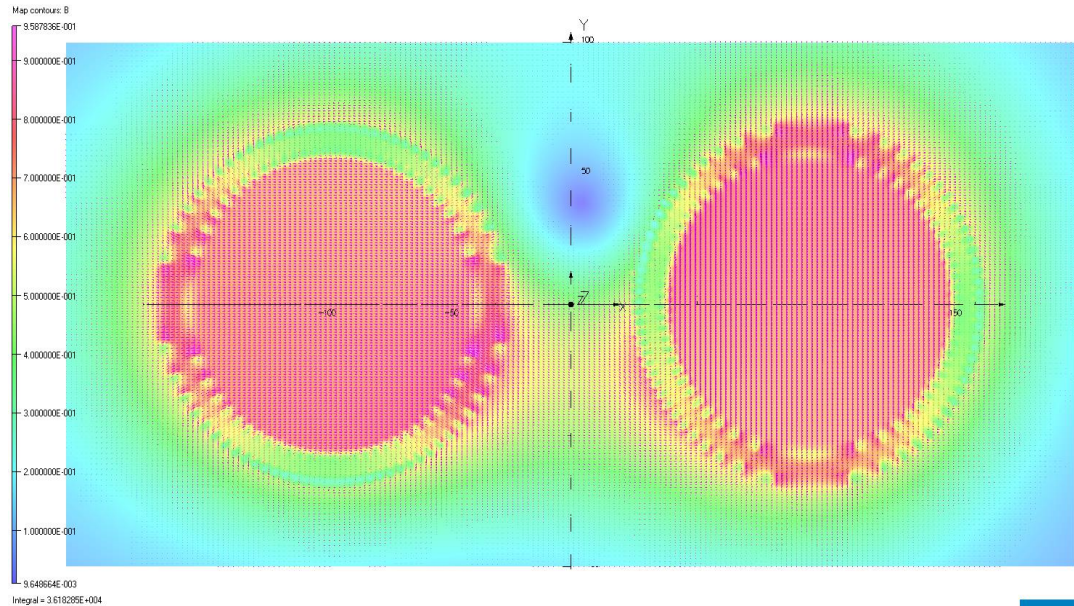
0.5m Model results

Peak field 1.71T



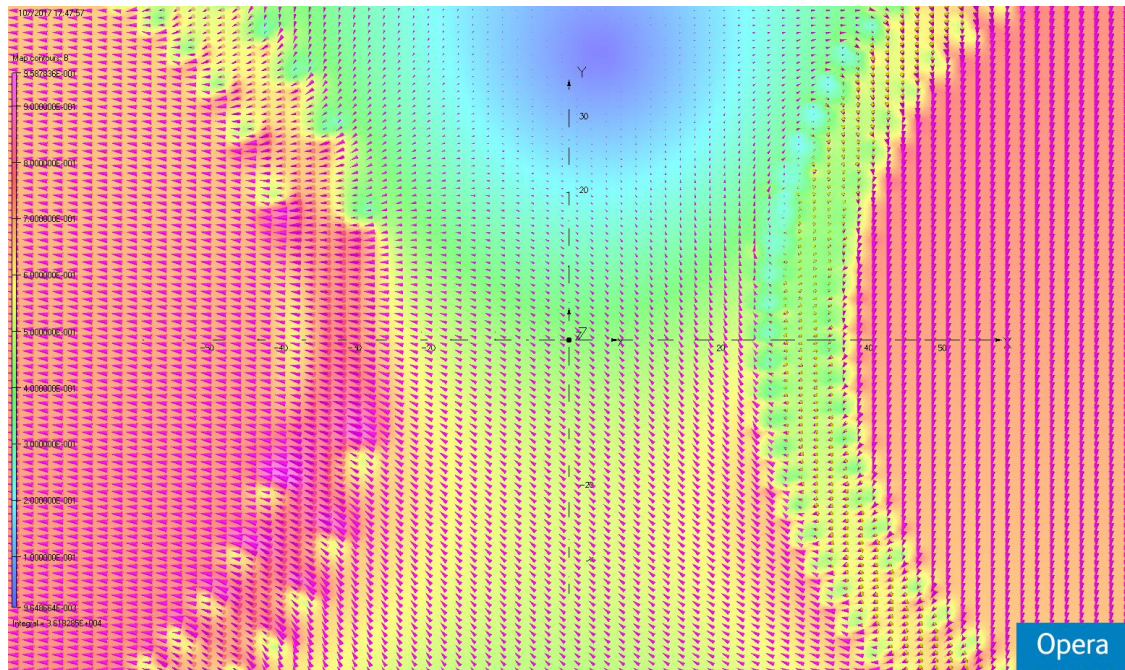
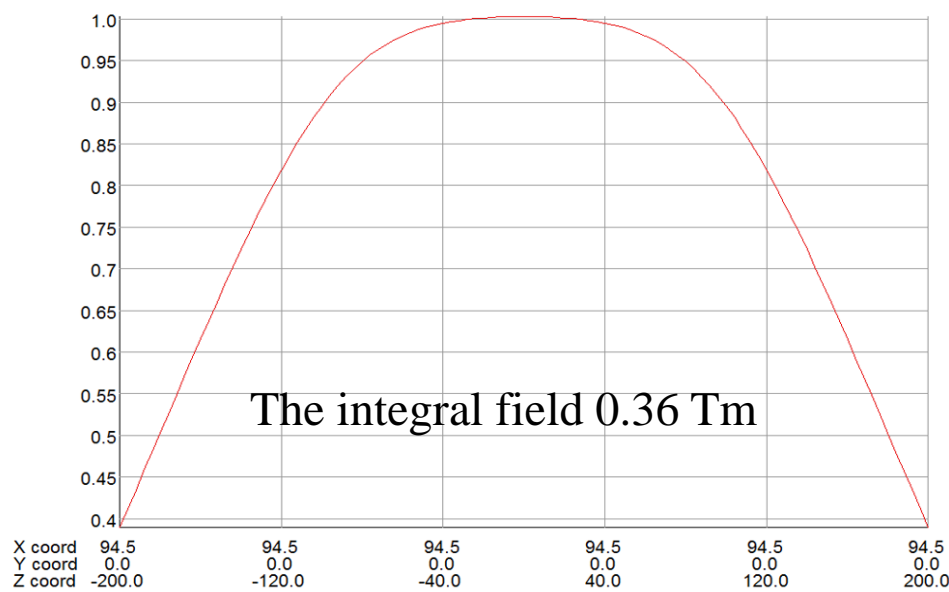
Peak field 1.25T
(bore field: 1T)





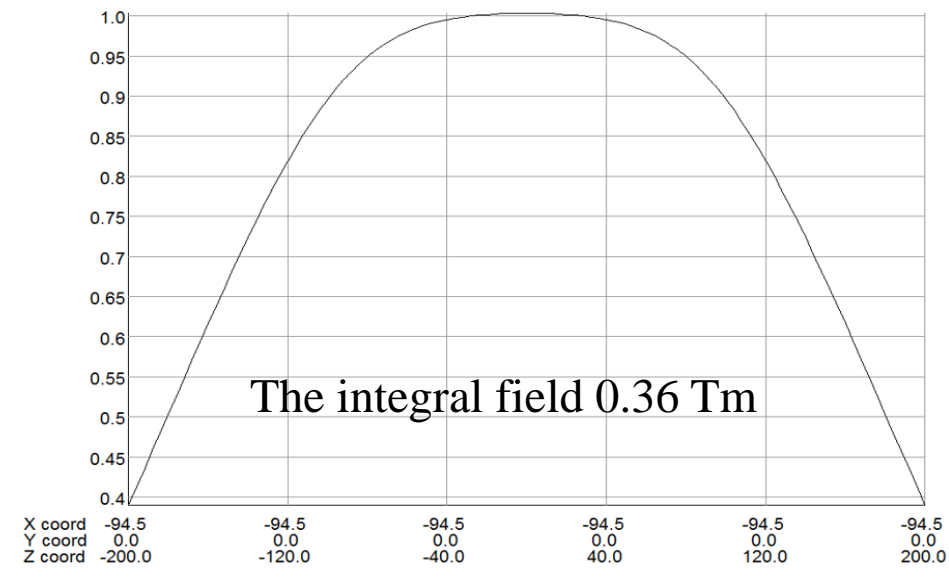
Opera

By along the axial direction in the right aperture



Opera

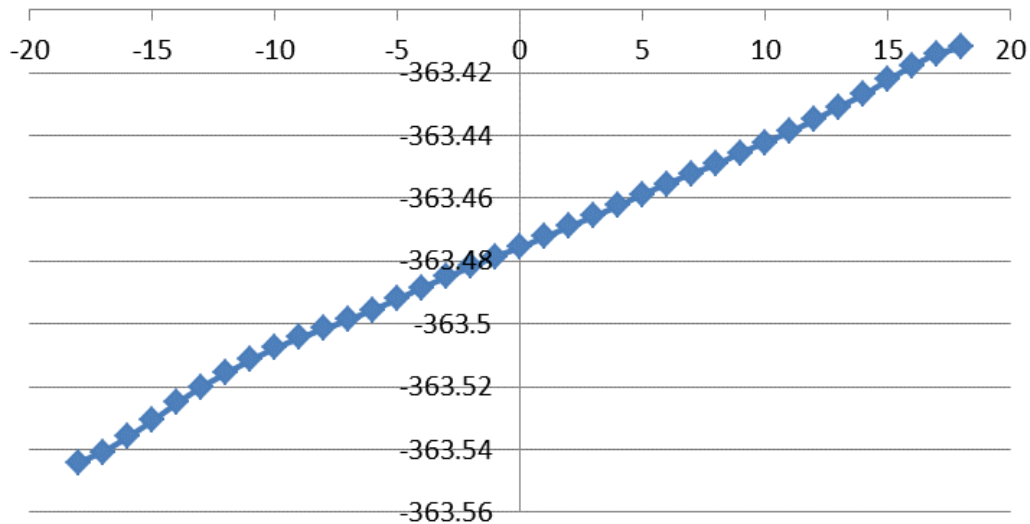
Bx along the axial direction in the left aperture



0.5m Model results

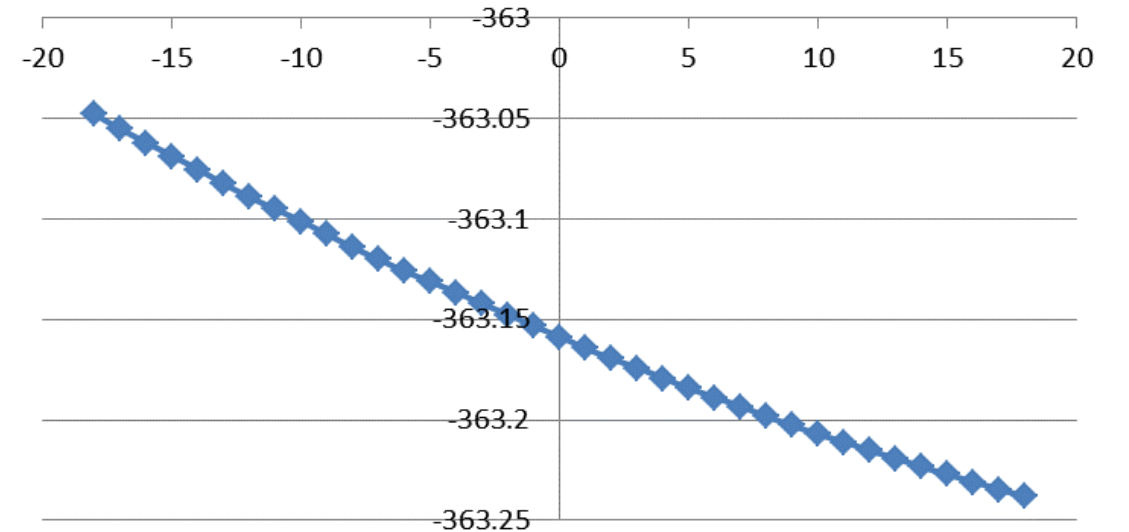
Left aperture

B1	-0.363 Tm
B2/B1	-1.51E-04
B3/B1	-9.67E-06
B4/B1	-2.91E-05
B5/B1	2.14E-05
B6/B1	1.36E-06
B7/B1	-5.61E-06



The integral field quality in the middle plane

B1	0.363 Tm
B2/B1	2.55E-04
B3/B1	-3.65E-05
B4/B1	-4.27E-06
B5/B1	-7.85E-06
B6/B1	3.88E-06
B7/B1	3.26E-06



Summary

- A very preliminary electromagnetic design of the HL-LHC CCT magnet has been done
- The core of the iron is saturated. The thickness of the iron core and the spacing between the coils are to be optimized
- The integral field is 5.1 Tm for the 2 m full model, higher than the required value. The higher order harmonics are all less than 10 unit with the reference radius of 35 mm
- A 0.5 m model will be fabricated firstly with 1*5 strand layout in the slot. The integral field is 0.36 Tm. The higher order harmonics are all less than 10 unit with the reference radius of 35 mm

Comments and suggestions