2003 LARP Collaboration Meeting

FNAL LARP Dipole R&D

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September 16-18, Danfords on the Sound, NY

Design parameters

Bore diameter – 130 mm;

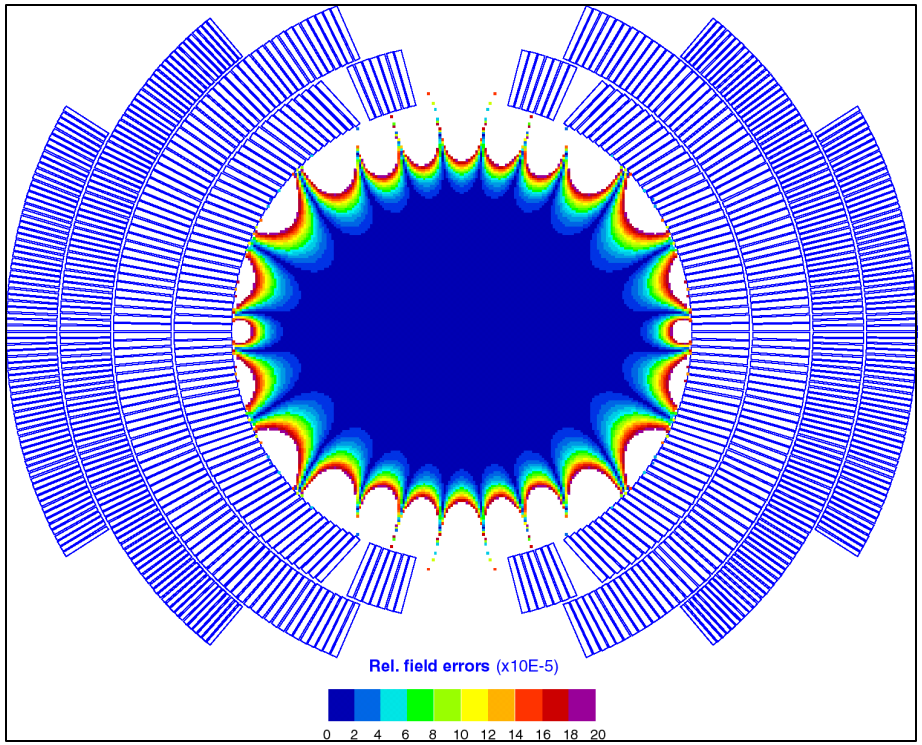
Nominal field – 13.5-14.5 T;

Length – 6-10 m;

Should withstand large heat depositions and radiation loads

Dipole coil design I

D_{bore} = 130 mm, Jc(12T,4.2 K) = 3000 A/mm^2



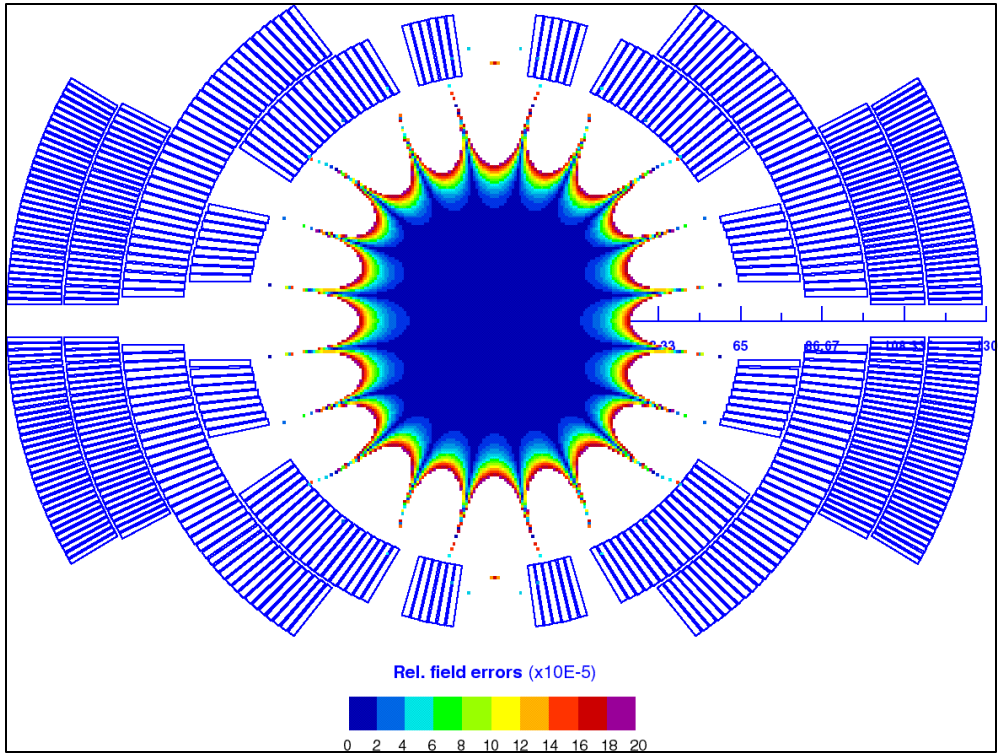
B_{q_bore} = 16.8 T
N_{turns} = 378
S_{coil} = 157.6 cm^2

Very good field quality and minimum number of wedges, but

would not work due to large heat depositions

Dipole coil design II

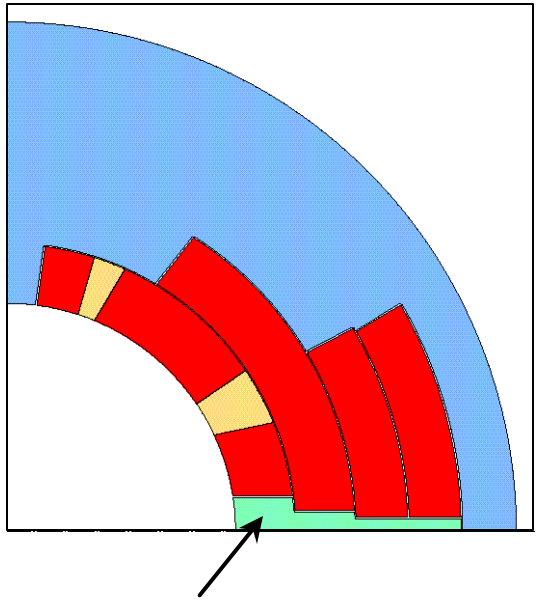
D_{bore} = 130 mm, Jc(12T,4.2 K) = 3000 A/mm^2



B_{q_bore} = 15.8 T

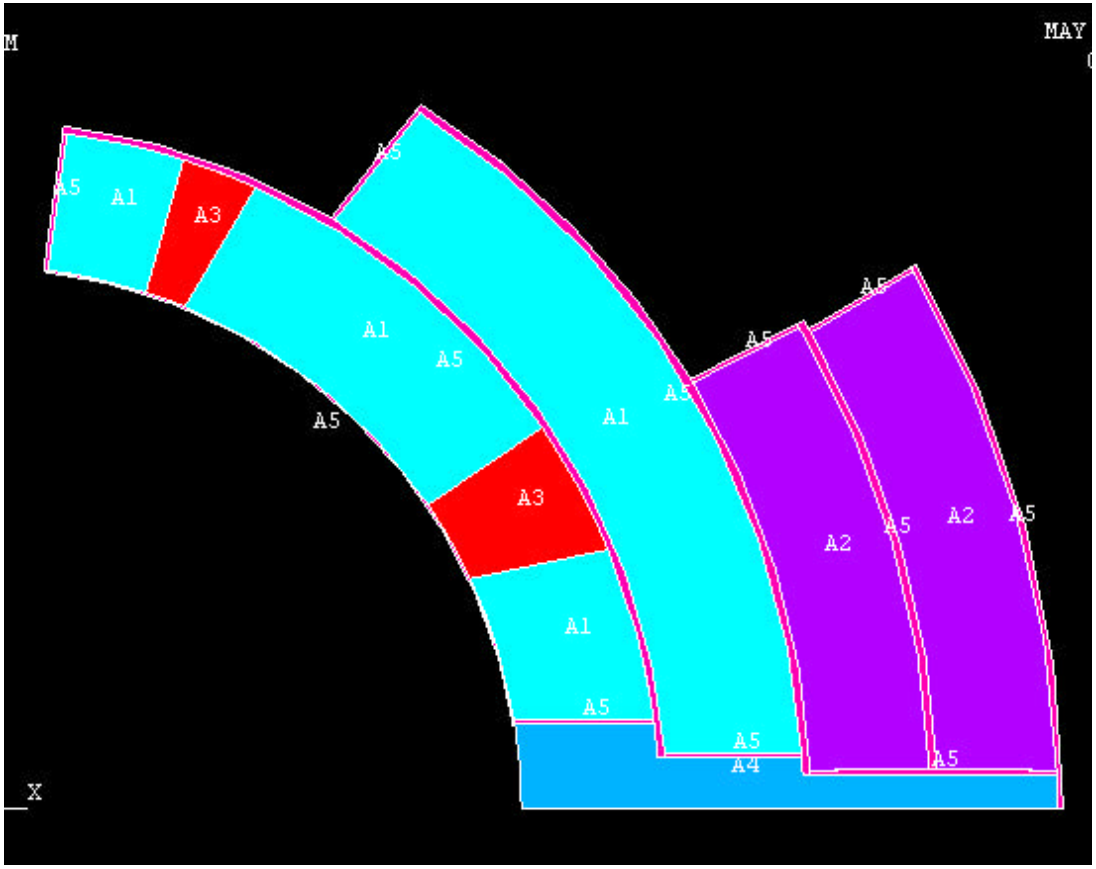
N_{turns} = 282

S_{coil} = 119.1cm^2



Copper spacer to remove heat

ANSYS thermal model



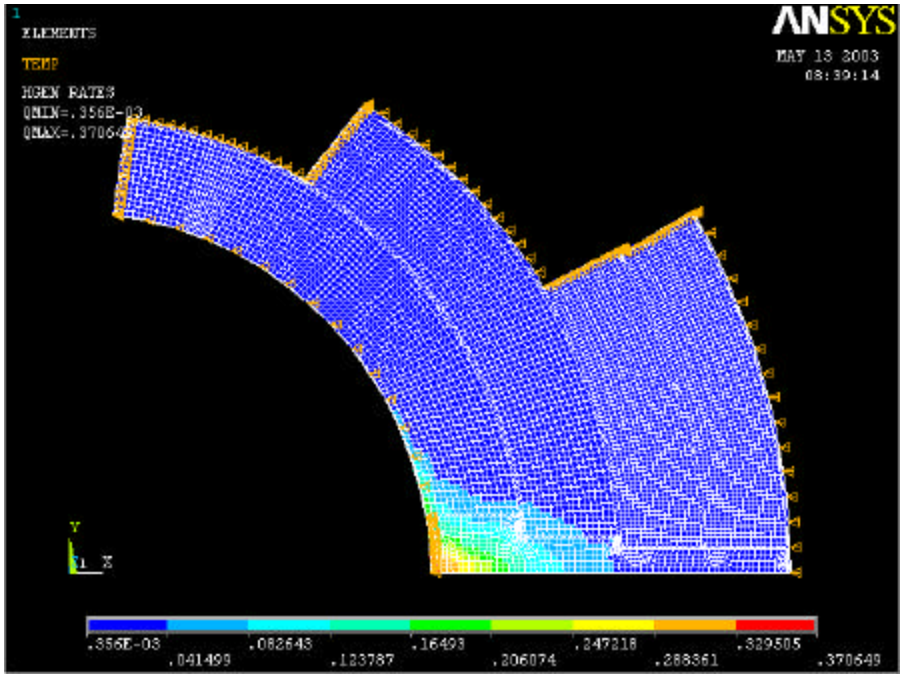
Thermal conductivity in mW/mm/K at 1.9 K

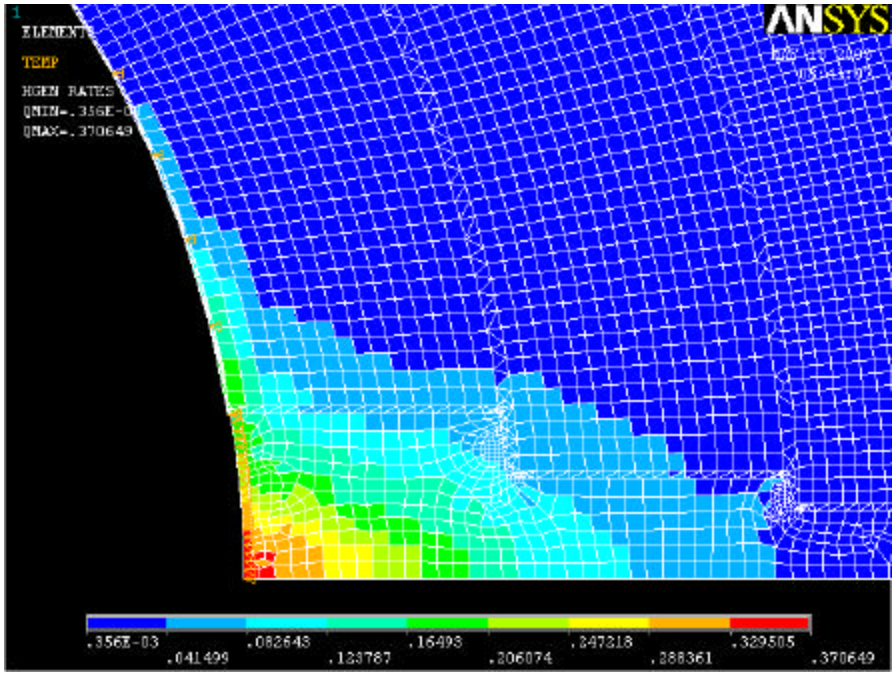
```
MATERIAL NUMBER =      1
 KXX   =   5.0000
 KYY   =  0.18000E-01
 KZZ   =   0.0000

MATERIAL NUMBER =      2
 KXX   =   5.0000
 KYY   =  0.18000E-01
 KZZ   =   0.0000

MATERIAL NUMBER =      3
 KXX   =   140.00

MATERIAL NUMBER =      4
 KXX   =   140.00

MATERIAL NUMBER =      5
 KXX   =  0.20000E-01
```

Coil perimeter was kept at 1.9 K

Heat deposition in the coil (from N. Mokhov)

Applied heat loads on coil elements in mW/mm^3

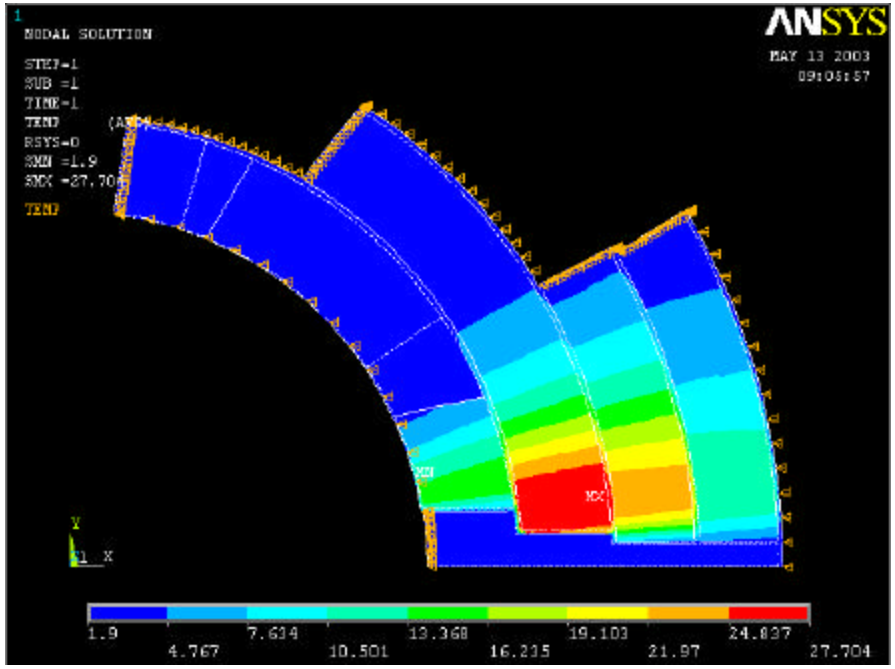




Q_{peak_spacer} = 49 mW/g, Q_{peak_coil} = 13 mW/g = 20 X $Q_{peak\_MQXB\_coil}$

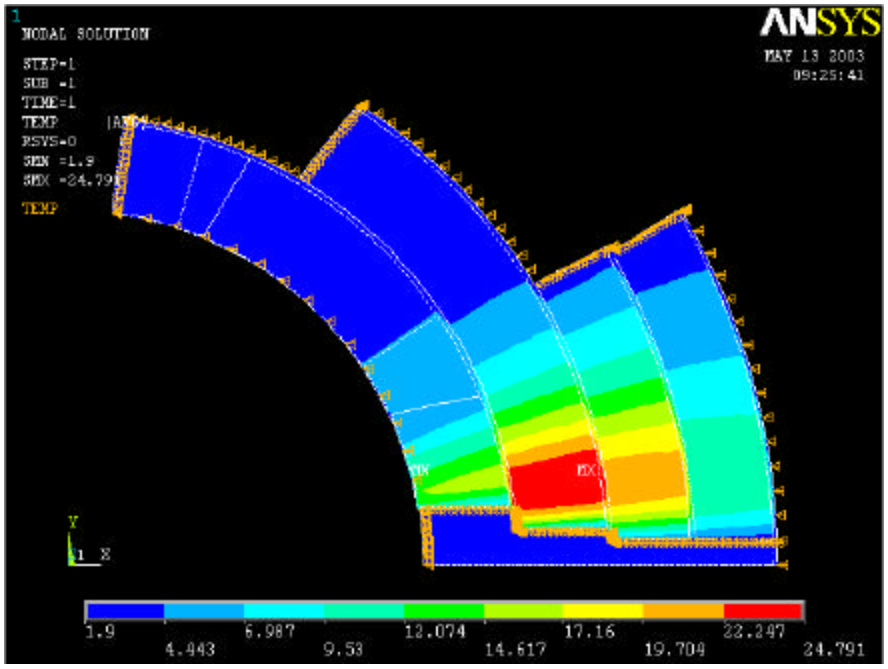
Dipole thermal analysis

External cooling



T_{peak} = 27.7 K

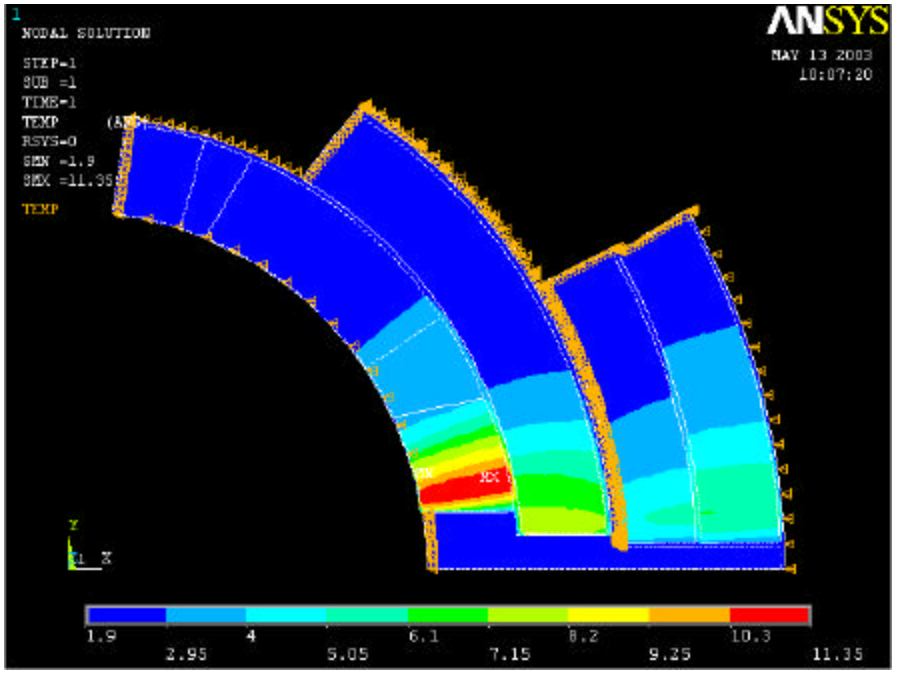
+Midplane cooling



T_{peak} = 24.8 K

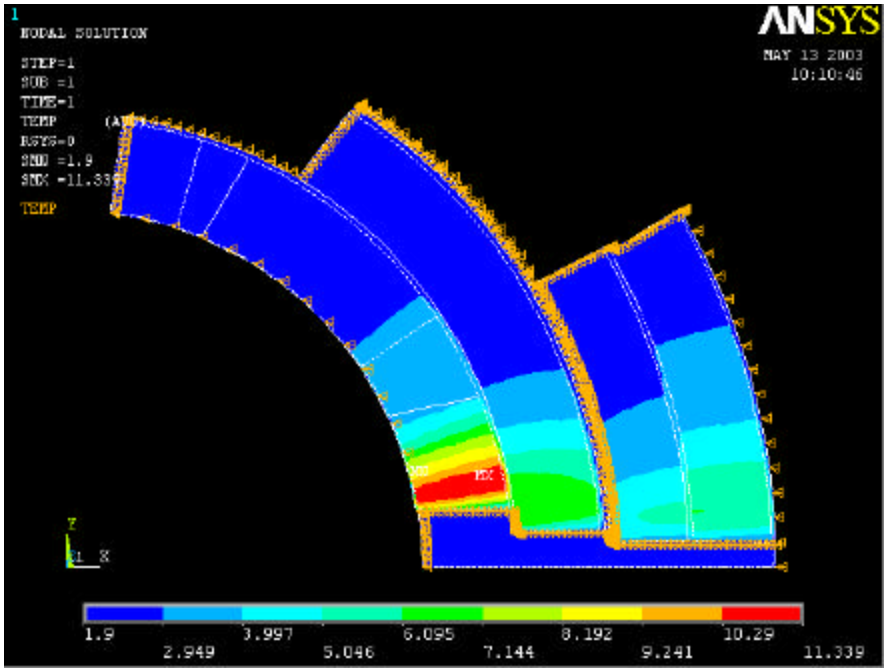
Dipole thermal analysis

External + interlayer cooling



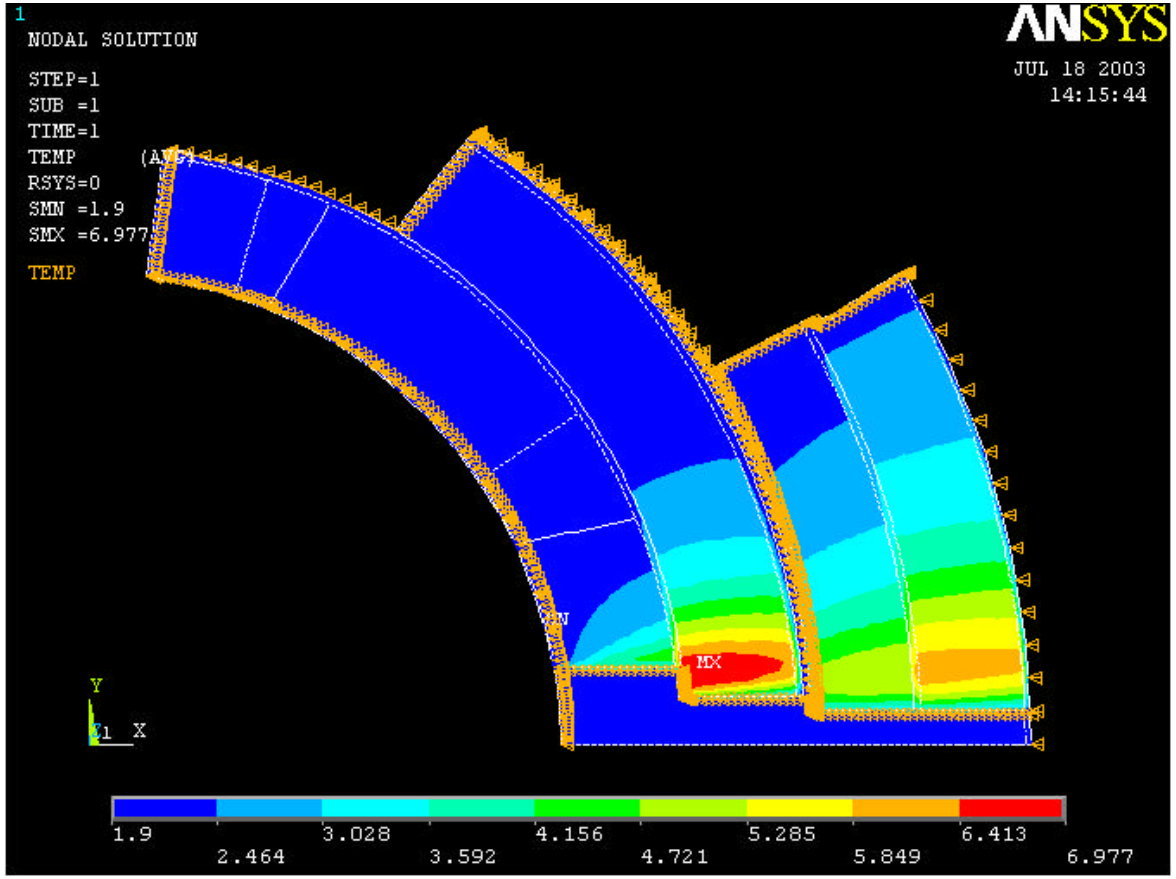
T_{peak} = 11.35 K

+Midplane cooling



T_{peak} = 11.34 K

Dipole thermal analysis



Perforated insulation at the inner coil surface can significantly reduce peak temperature

$T_{peak} = 7$ K

Issues for R&D

Mechanics, quench protection, cryogenics…

Even though a solution for coil cooling can be found, the design looks extremely challenging:

Half-coils pull to each other with 12.6 MN/m;

Peak pressure in the midplane exceeds 270 MPa;

Stored energy is 4 MJ/m = 6 x LHC dipole;

Inductance is 53 mH/m = 7 x LHC dipole;

Total power dissipation per (10m) dipole is 3.5 kW = 1.5 x LHC refrigeration units (1.8K).