Preliminary Magnetic Design of Room Temperature NSLS2 Dipoles

Ramesh Gupta

Overview

Preliminary 2d design for

(a) Curved 60 mm good field aperture magnet

(b) Straight 90 mm good field aperture magnet

Preliminary 3d design calculations

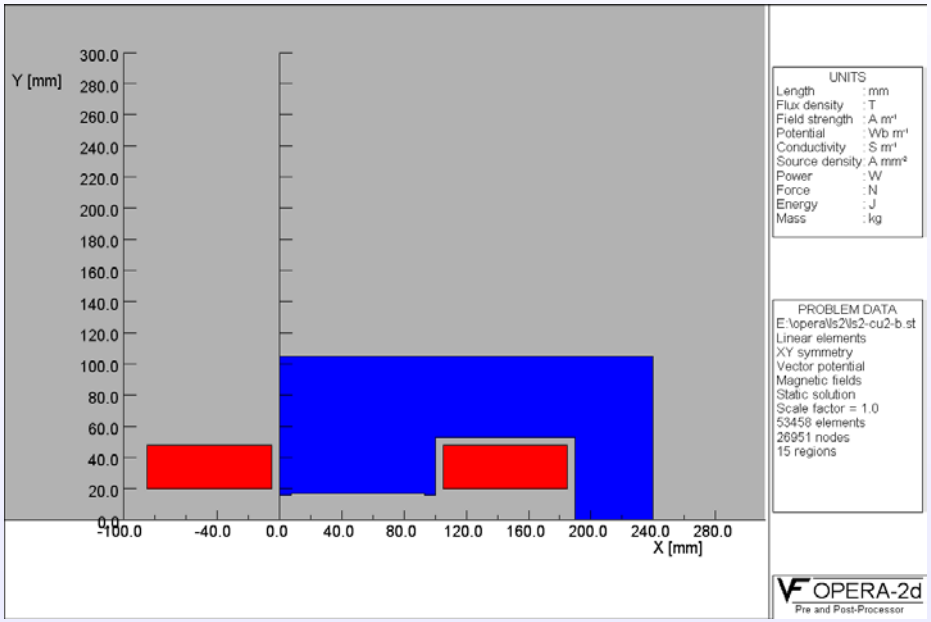
- Iron cap to cut field fall off beyond magnet ends
- A possible design concept to significantly reduce loss in space due to magnet ends

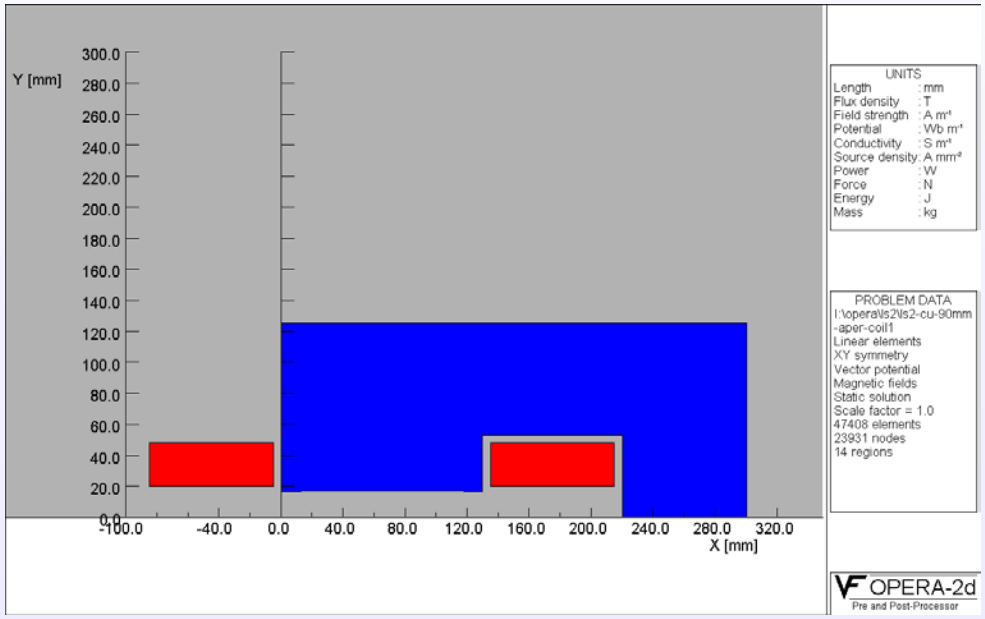
Basic design assumptions

(a) Copper current density : 2 Amp/mm^2

(b) Vertical iron gap 34 mm

Magnetic Models of 3 kG Magnet Designs for Light Source 2 (LS2)

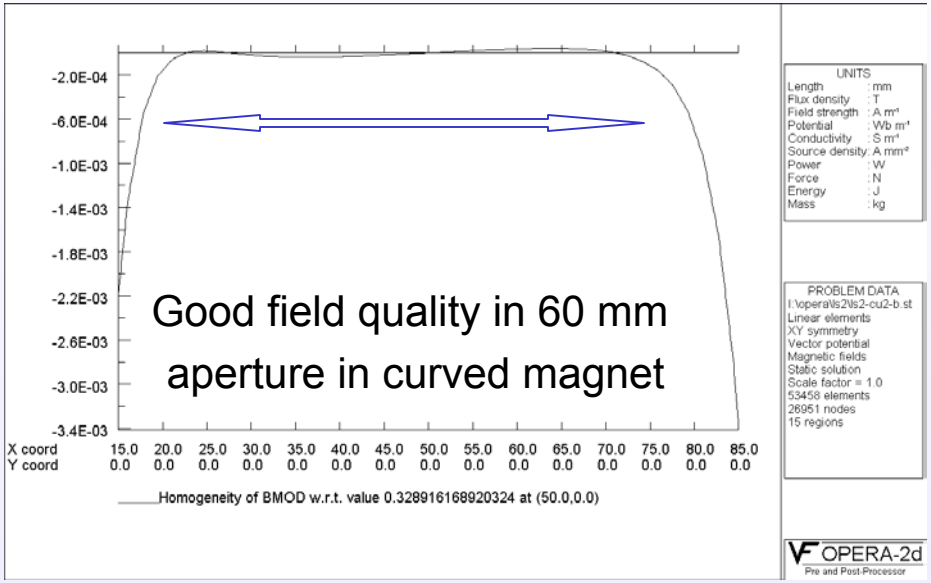


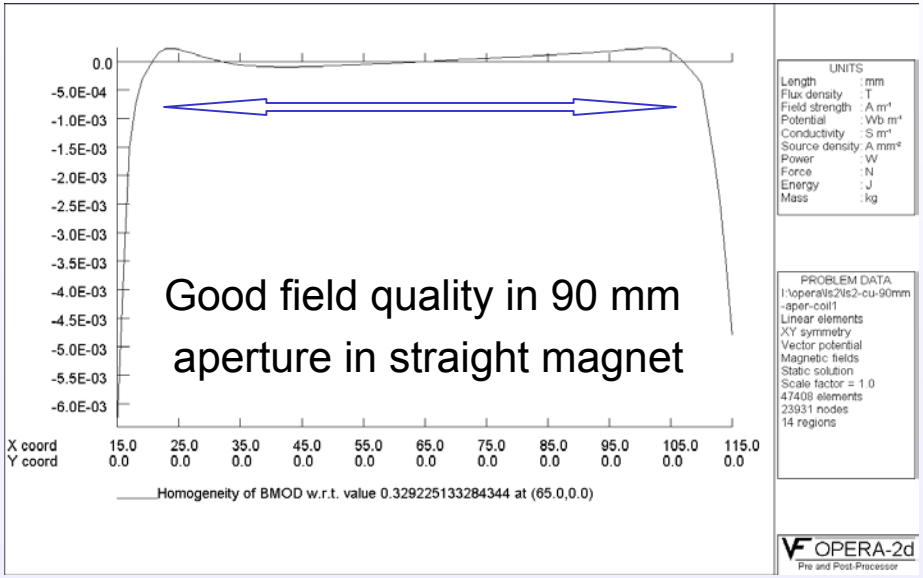


Water-cooled copper magnet
60 mm good field aperture (curved)
Current Density = 2 A/mm^2

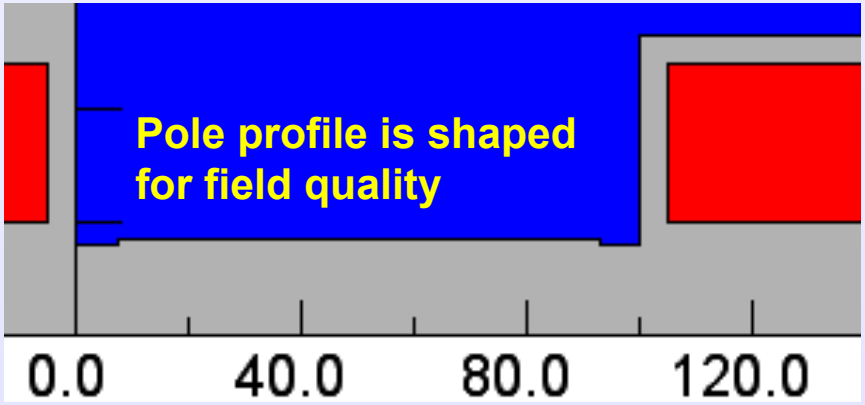
Water-cooled copper magnet
90 mm good field aperture (straight)
Current Density = 2 A/mm^2

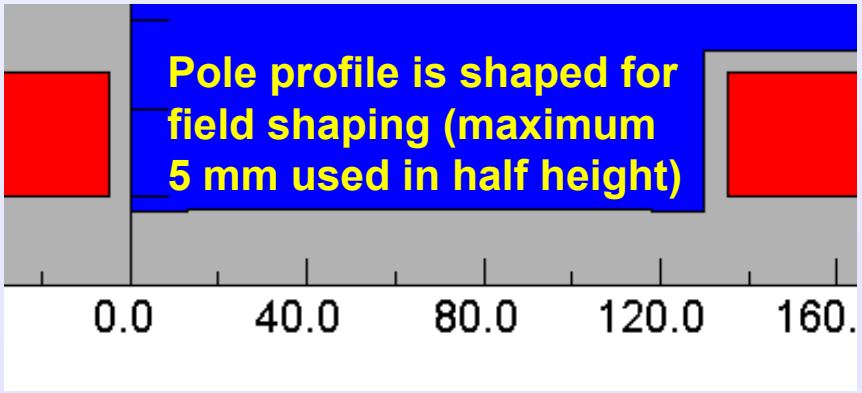
Field Quality in Preliminary Design



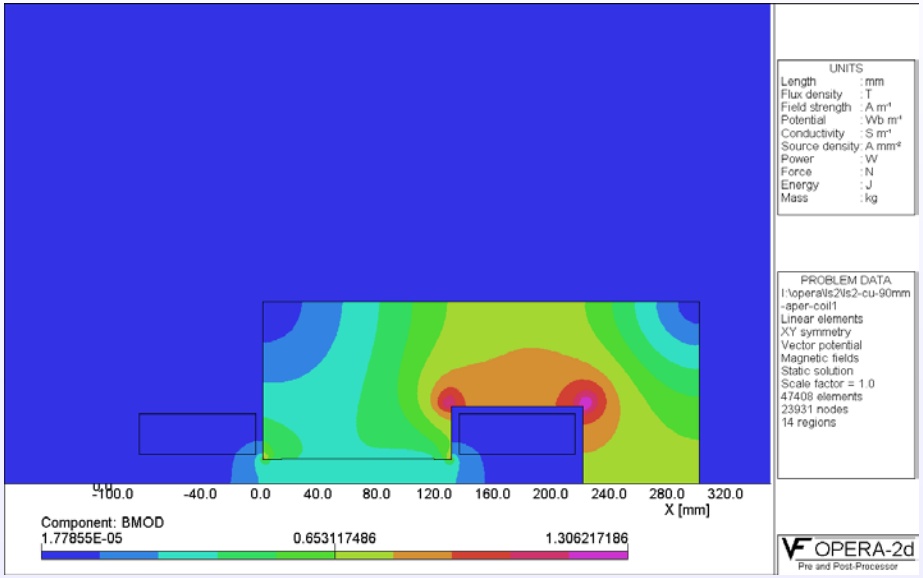


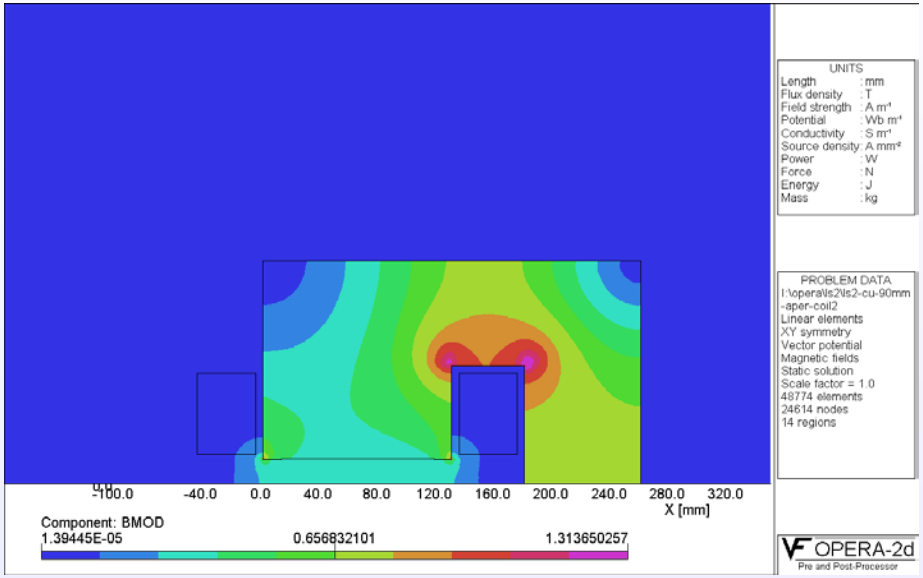
These are preliminary conceptual designs. Nevertheless the field quality requirements of a few parts in 10^{-4} have been obtained by shaping the pole (5 mm max, vertically).





Guidance on Coil Design



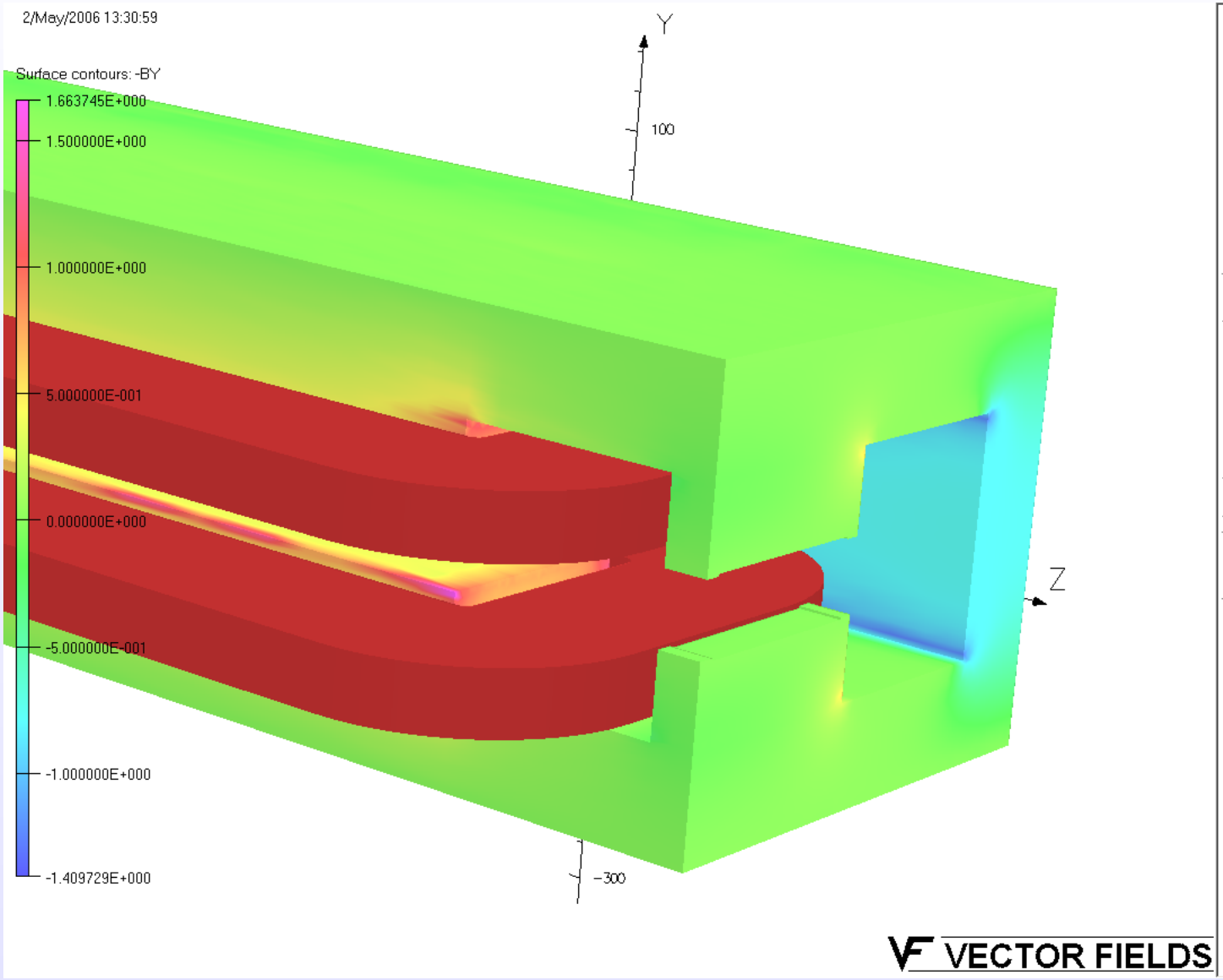


Coil dimensions in design 1:
80 mm X 28 mm

Coil dimensions in design 2:
40 mm X 56 mm

- **What is the preferred direction for coil cross-section?**
- **Should coil be further above the pole tip?**
- **Should they be lifted/tilted on one side (left side)? In the ends?**

Field in Iron With Fe Cover in the Ends



UNITS

Length	mm
Magn Flux Density	T
Magn Field	A m^{-1}
Magn Scalar Pot	A
Magn Vector Pot	Wb m^{-1}
Elec Flux Density	C m^{-2}
Elec Field	V m^{-1}
Conductivity	S mm^{-1}
Current Density	A mm^{-2}
Power	W
Force	N
Energy	J

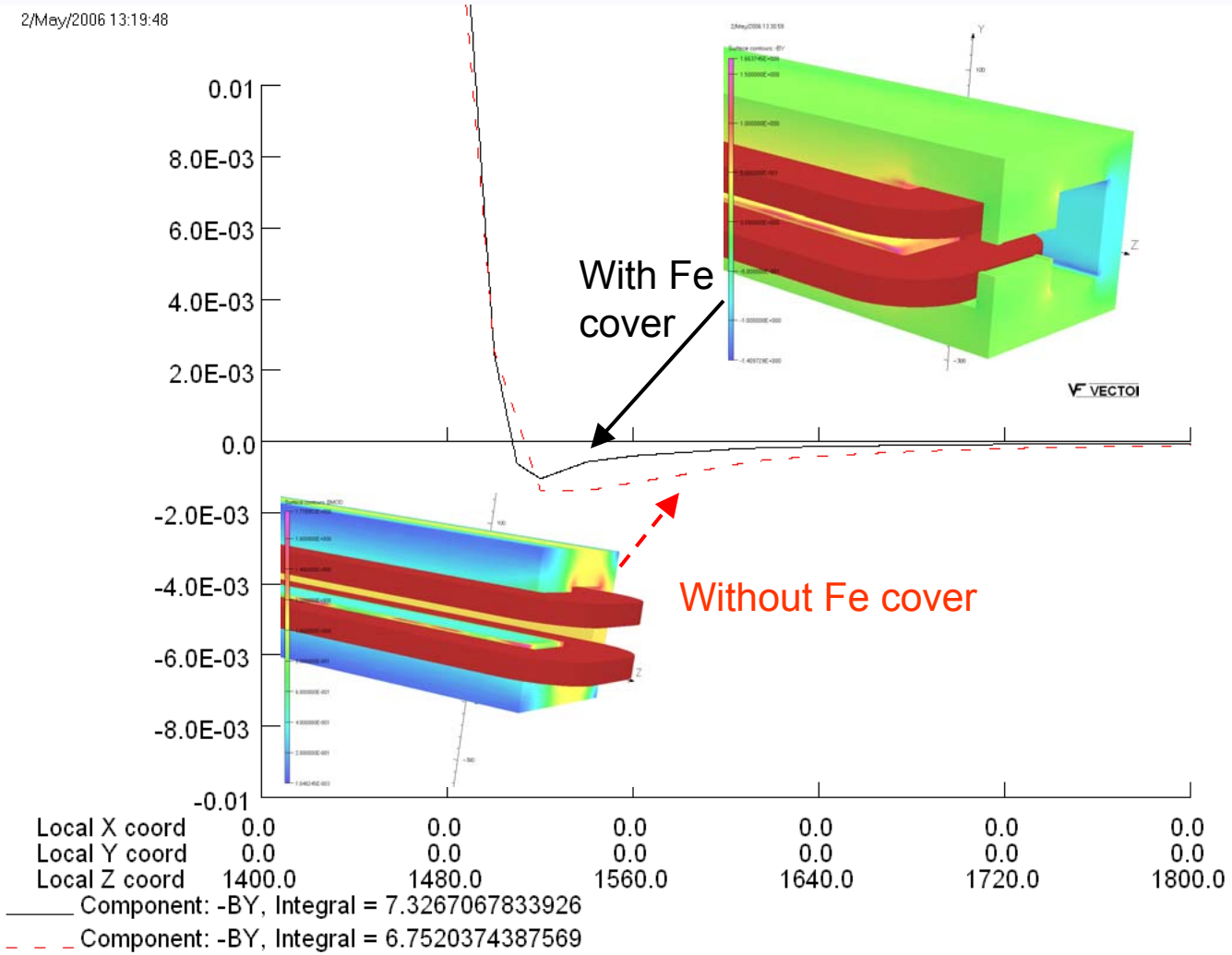
PROBLEM DATA

ls2-cu-b4.op3
TOSCA Magnetostatic
Non-linear materials
Simulation No 1 of 1
2220221 elements
376671 nodes
1 conductor
Nodally interpolated fields
Reflection in XY plane (Z field=0)
Reflection in ZX plane (Z+X fields=0)

Local Coordinates

Origin: 0.0, 0.0, 0.0
Local XYZ = Global XYZ

Field Away From The Magnet With and Without Fe Cover



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Elec Field	V m^{-1}
Conductivity	S mm^{-1}
Current Density	A mm^{-2}
Power	W
Force	N
Energy	J

PROBLEM DATA
ls2-cu-b2.op3
TOSCA Magnetostatic
Non-linear materials
Simulation No 1 of 2
2149432 elements
364713 nodes
1 conductor
Nodally interpolated fields
Reflection in XY plane (Z field=0)
Reflection in ZX plane (Z+X fields=0)

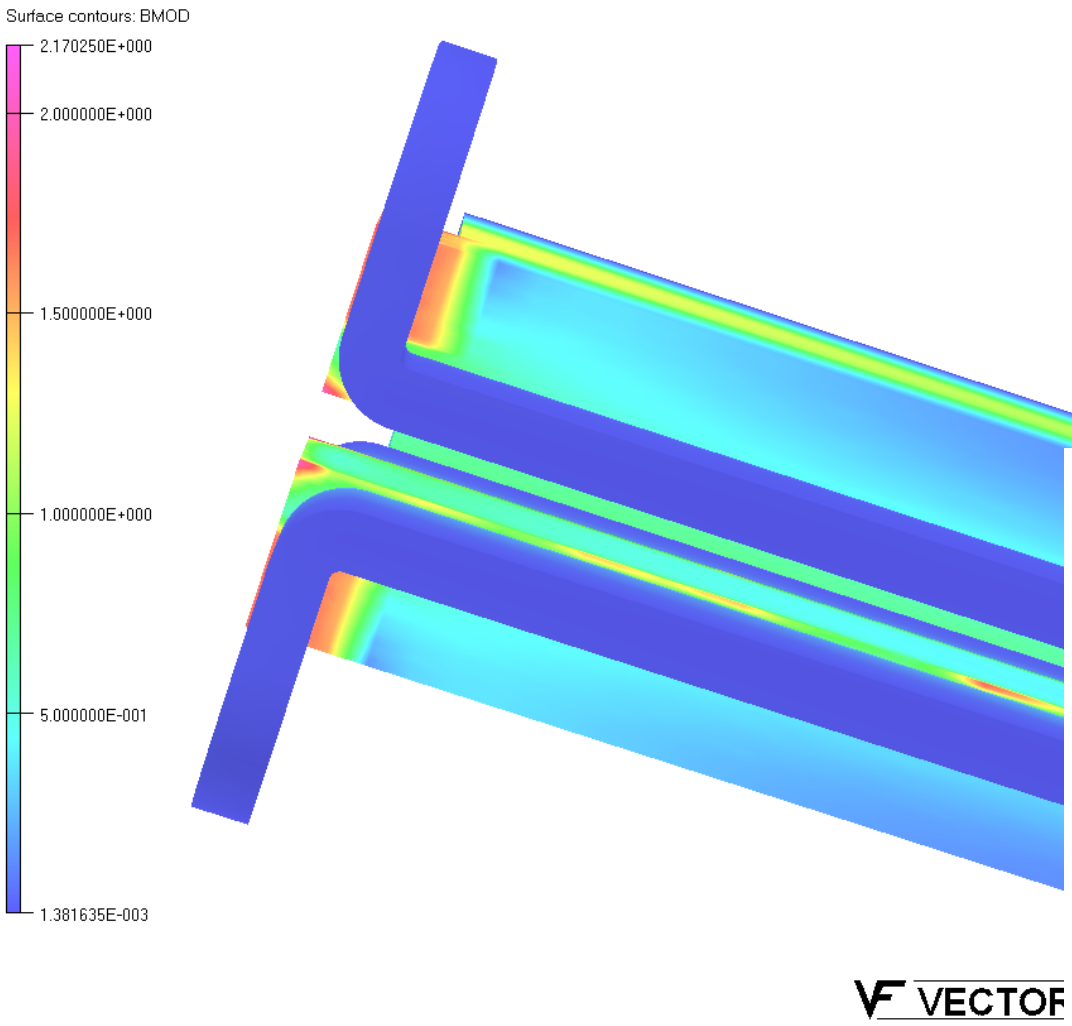
Local Coordinates
Origin: 0.0, 0.0, 0.0
Local XYZ = Global XYZ

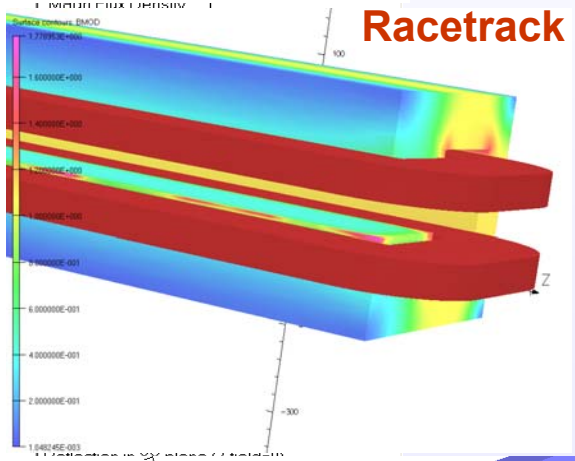
VECTOR FIELDS

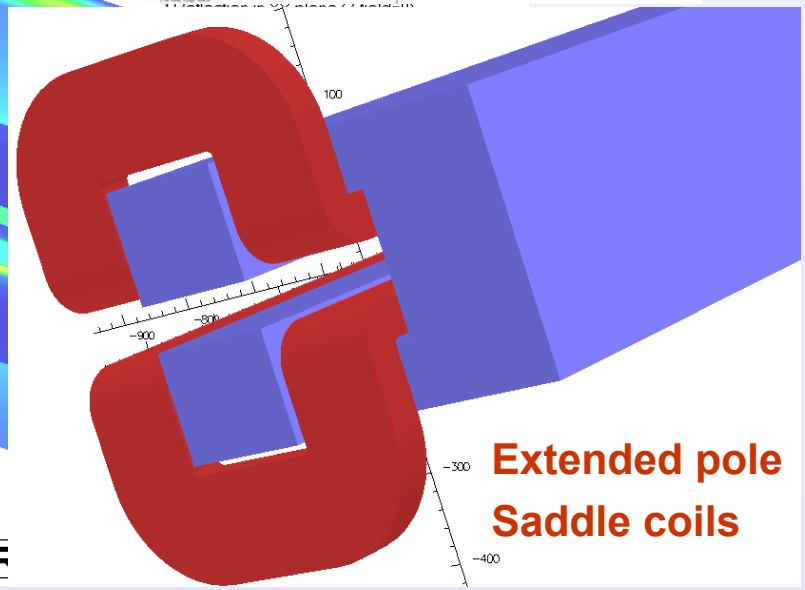
Extended Pole Piece to Eliminate Loss in Magnetic Length Due to Coil Ends

An investigation to see if magnetic length can be determined by pole only and loss in length due to coil ends can be freed-up for other purpose.

Regular iron
Racetrack coils

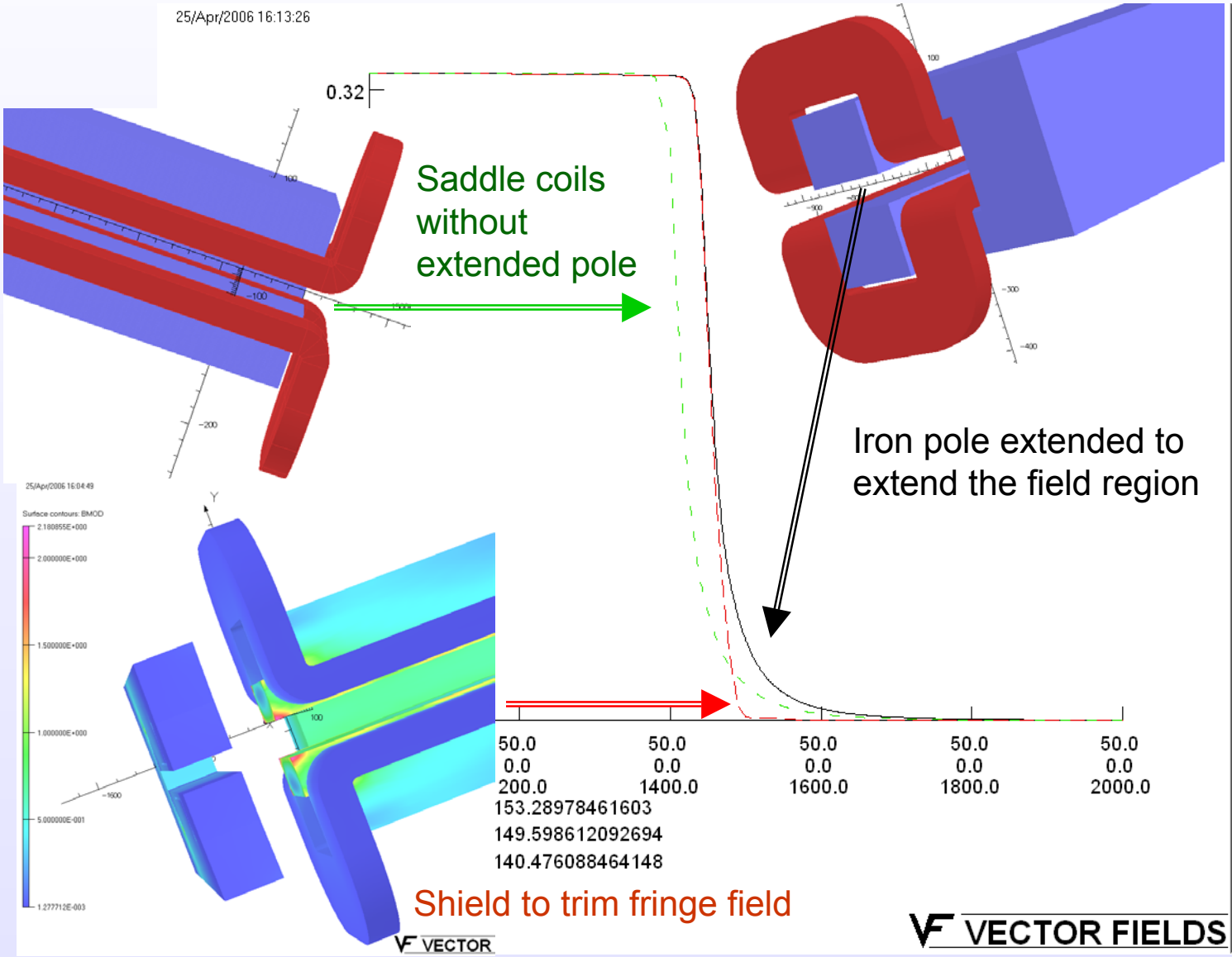






Extended pole
Saddle coils

Magnet Ends Optimized For Machine



UNITS

Length	mm
Magn Flux Density	T
Magn Field	A m^{-1}
Magn Scalar Pot	A
Magn Vector Pot	Wb m^{-1}
Elec Flux Density	C m^{-2}
Elec Field	V m^{-1}
Conductivity	S mm^{-1}
Current Density	A mm^{-2}
Power	W
Force	N
Energy	J

PROBLEM DATA

ls2-cu-e1c1.op3
TOSCA Magnetostatic
Non-linear materials
Simulation No 1 of 1
2901376 elements
490981 nodes
1 conductor
Nodally interpolated fields
Reflection in XY plane (Z field=0)
Reflection in ZX plane (Z+X fields=0)

Local Coordinates

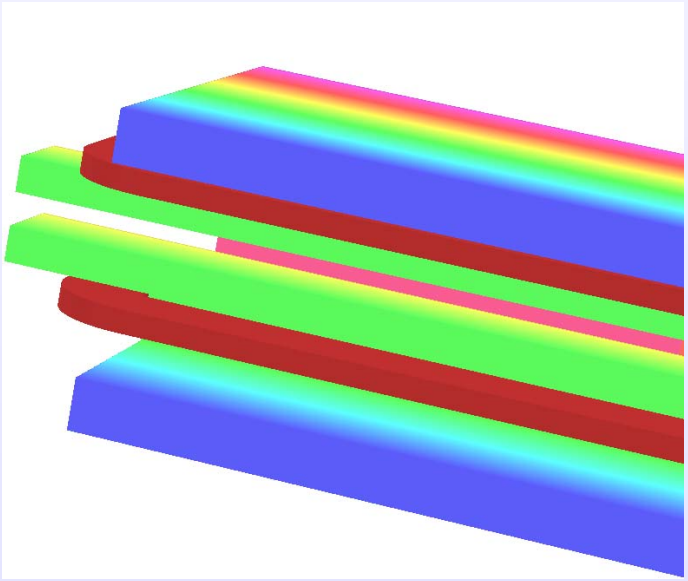
Origin: 0.0, 0.0, 0.0
Local XYZ = Global XYZ

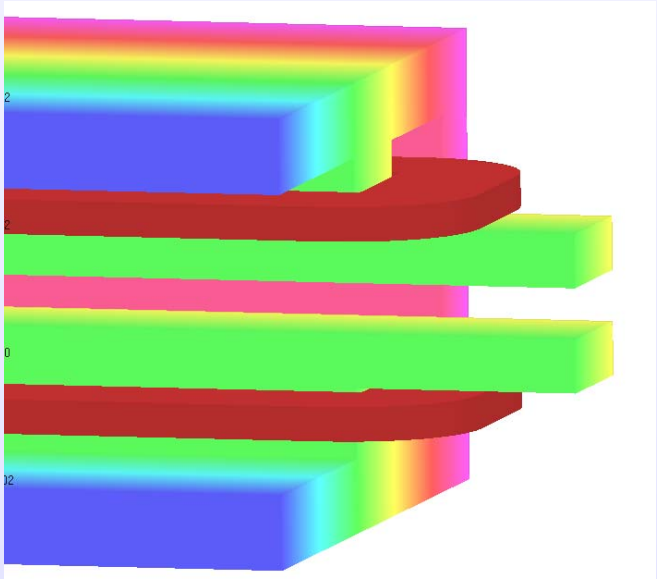
Freeing Up Loss in Space Due to Magnet Ends By Extending Pole

With some adjustments, one can get similar gains in racetrack coils too.

Space freed-up (made available for other purpose) is ~15 cm between two magnet ends. (Note, we are taking advantage of low field in poles).

Anyone interested? Is it useful? Is it worth some small complications?





Summary

- Preliminary investigation of water-cooled dipole magnet design has been made.
- Some interesting variations in the design have also been examined.
- We can move forward to finish this design study with some guidance.