Few considerations about the coil, the return yoke and the field quality

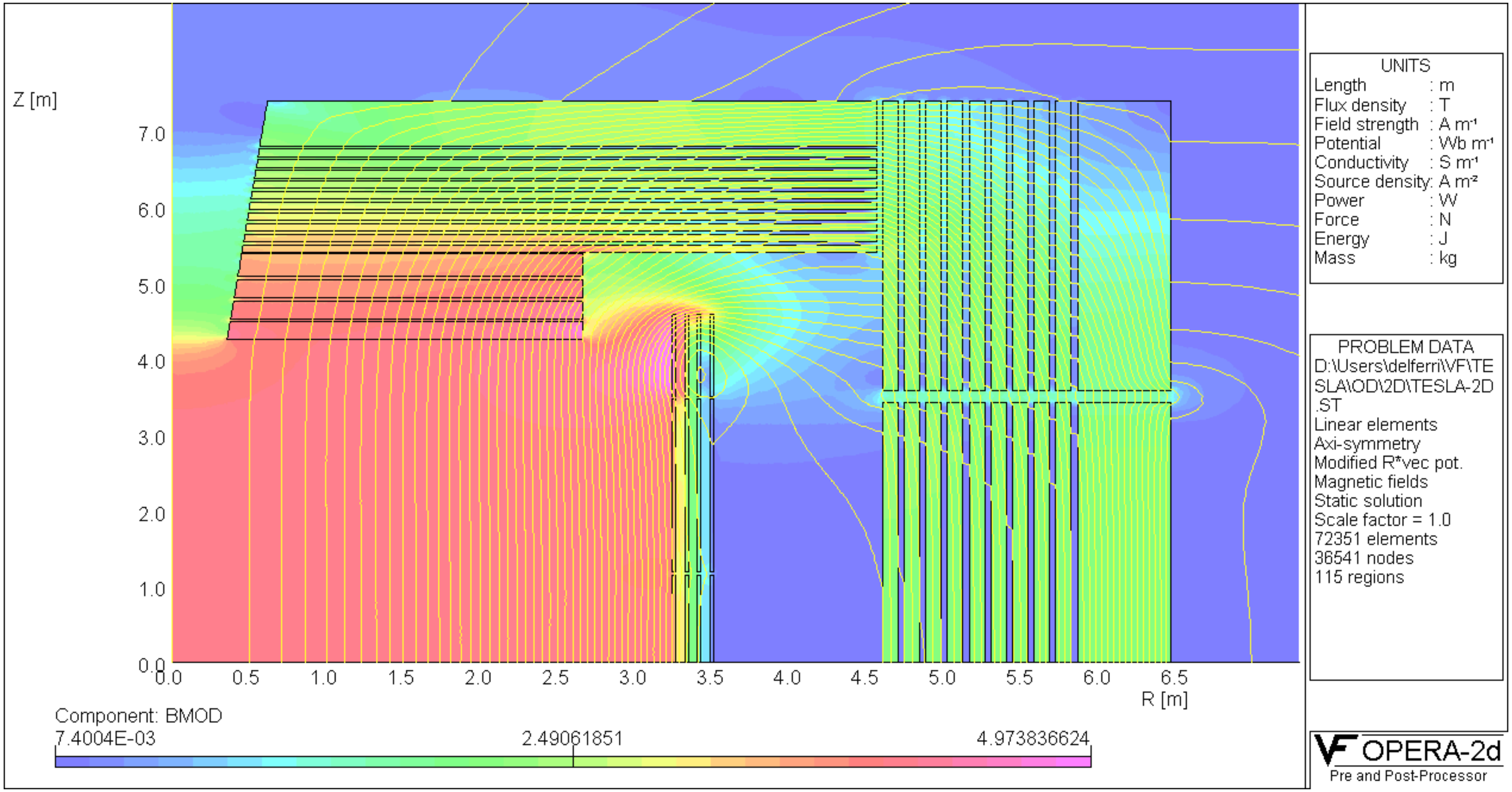
Henri Videau
LLR-Ecole polytechnique

1- question of return flux
2- field quality for TPC

Results and drawings
from F. Kircher
and O. Delferrière
CEA-Saclay

Solenoid Magnetic Calculations

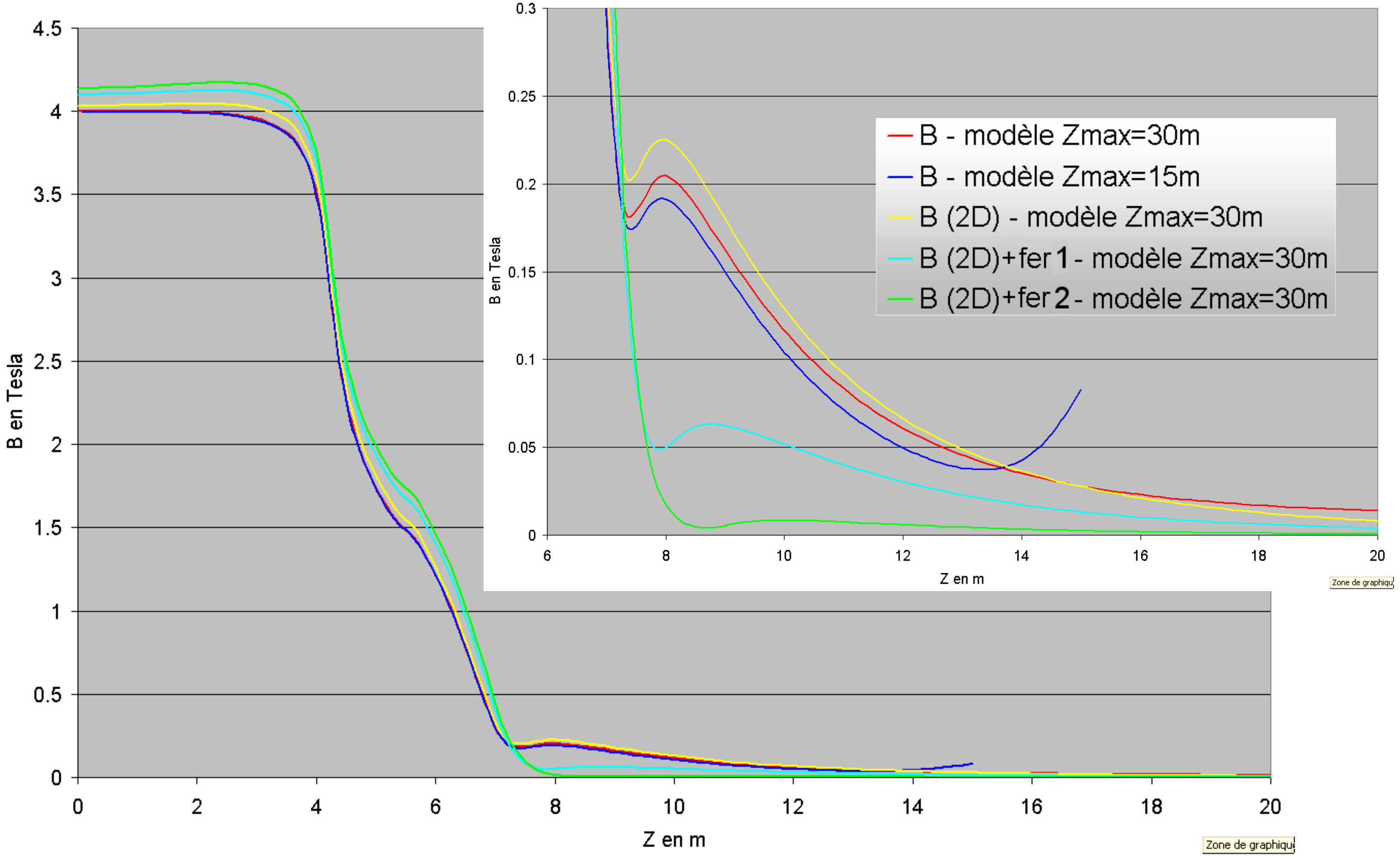
Because of axial symetry assumed in previous simulations with TOSCA :
⇨ New 2D model built with higher accuracy mesh to study leakage field



Note the chimney for helium, cables etc .. should not go all around

Presented by F. Kircher at nanobeam 2005

Solenoid Magnetic Calculations

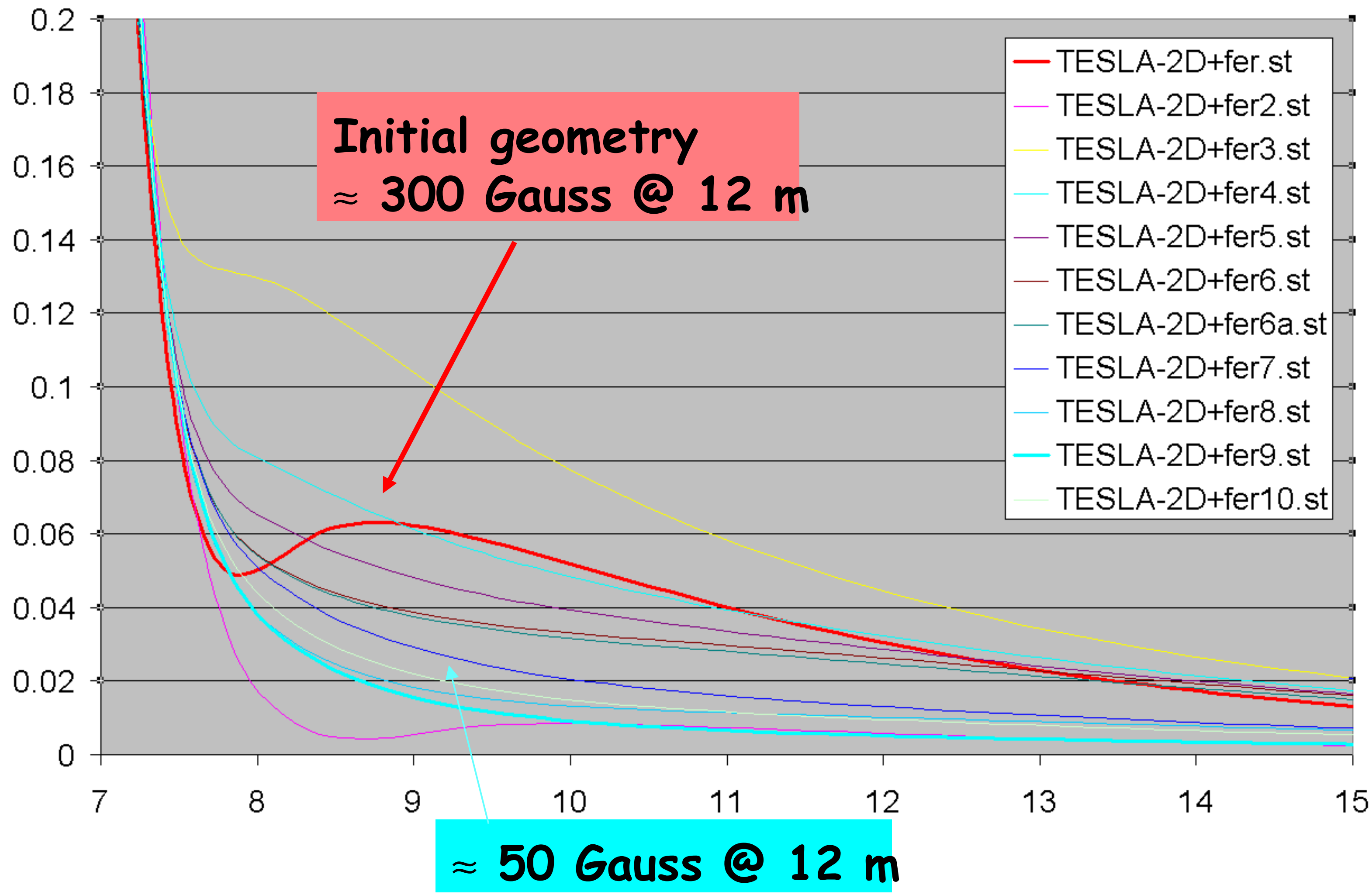


Leakage field can be dramatically reduced :

⇨ by adding iron at detector exit but also radialy at external radius

Solenoid Magnetic Calculations : leakage

Various design by adding iron to initial geometry



To improve the stray field

Know what has to get in and out of the magnet!
Design the holes.

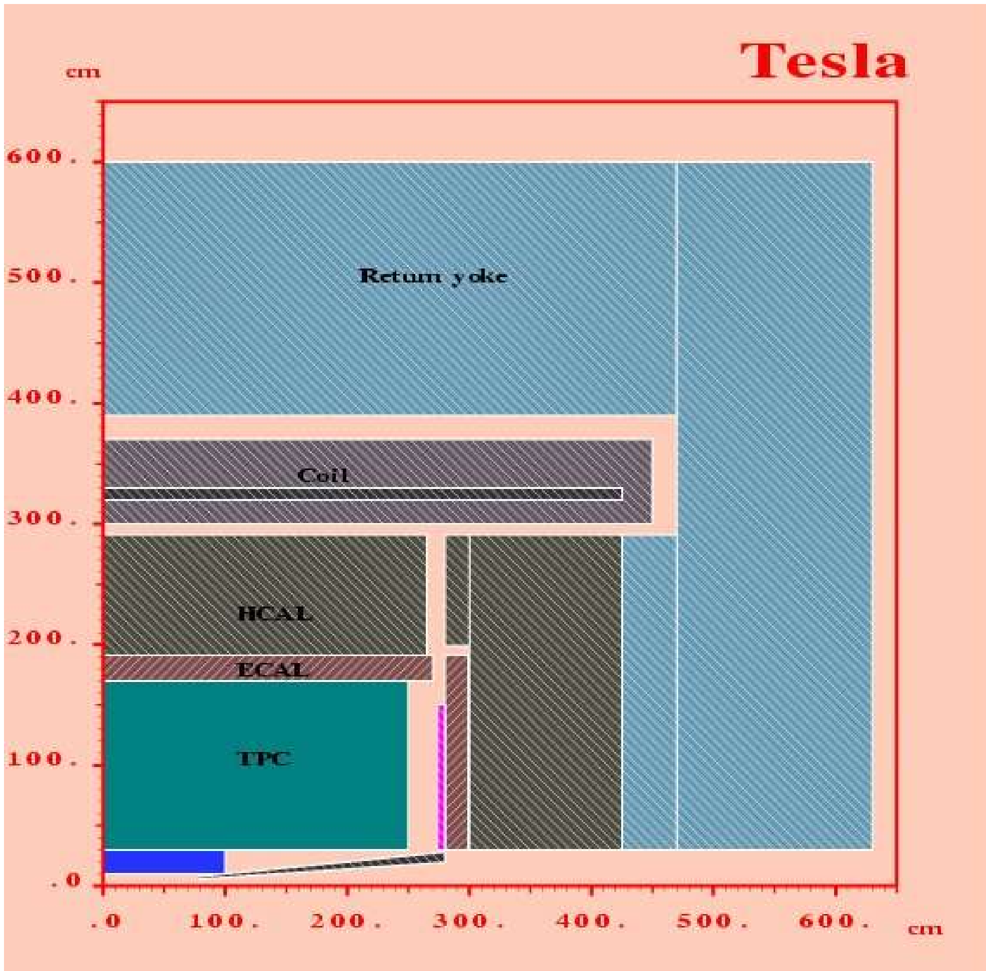
Do not break the iron when the field goes below saturation
Is there any point to have the end cap Hcal in iron instead of SS

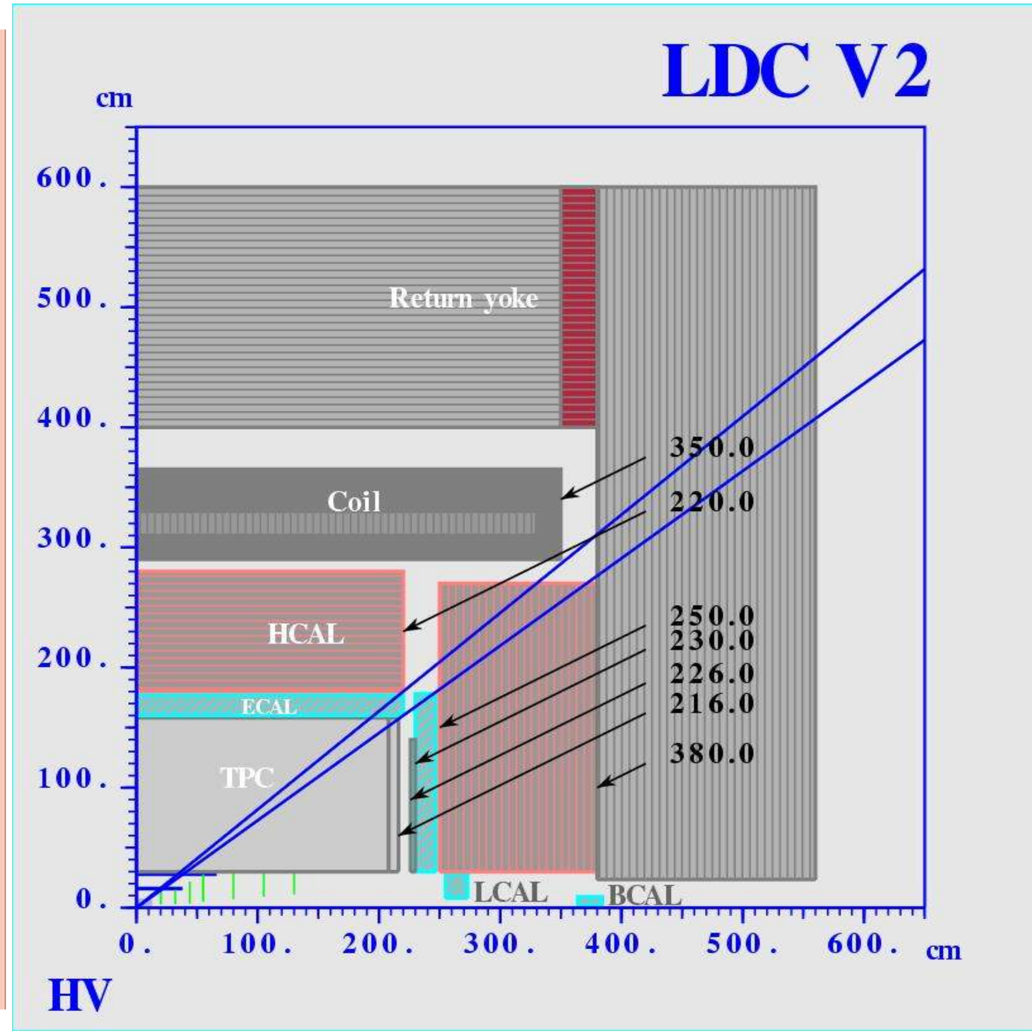
What about the muon chambers? role / impact

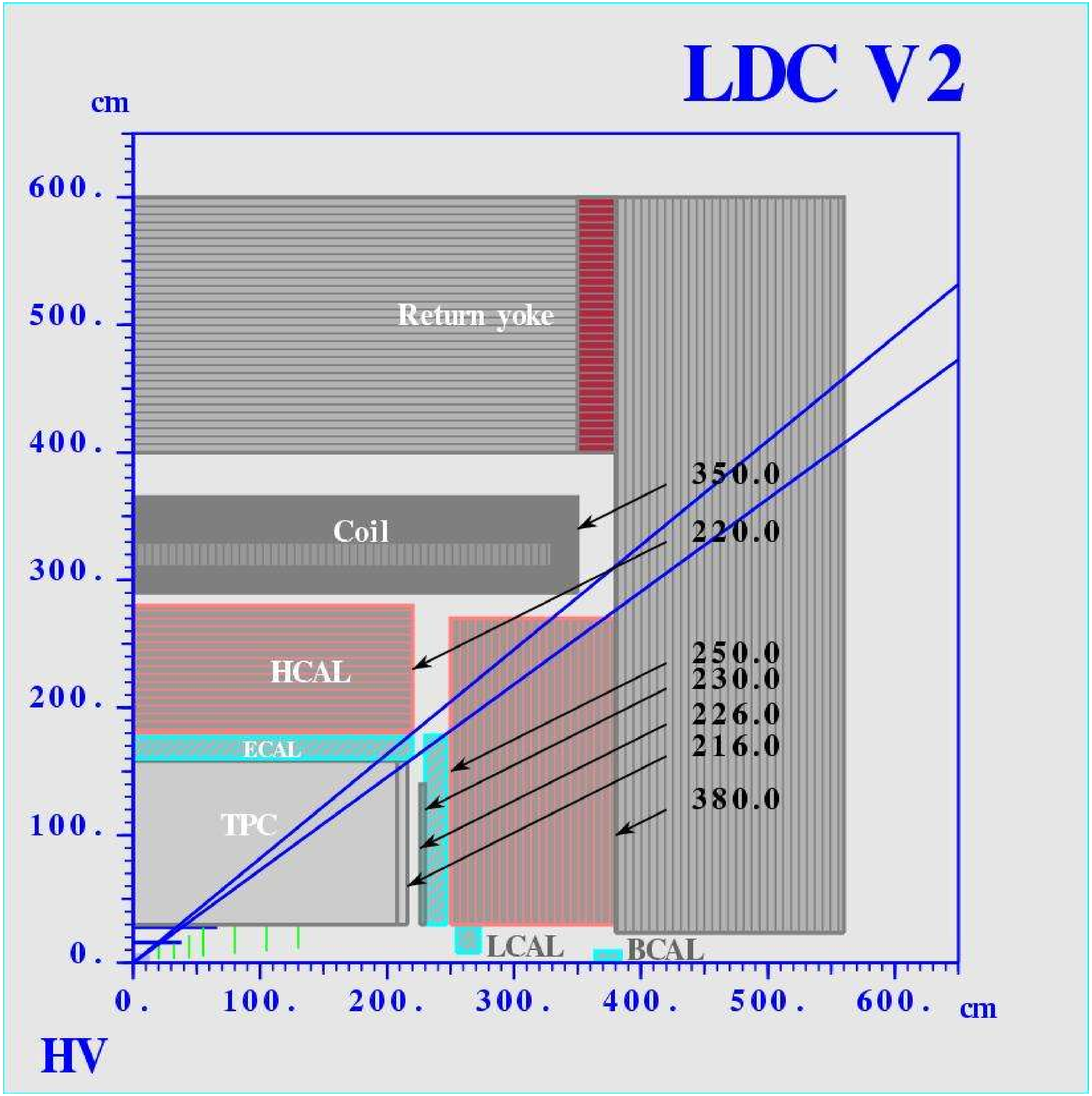
The Tesla magnet had been designed for $\int B_r/B_z \, dz < 2mm$

Can we keep the same quality of field with a shorter coil?

(forgetting for a moment about the DID)


Tesla
cm
600.
500.
400.
300.
200.
100.
.0
Return yoke
Coil
HCAL
ECAL
TPC
.0
100.
200.
300.
400.
500.
600.
cm

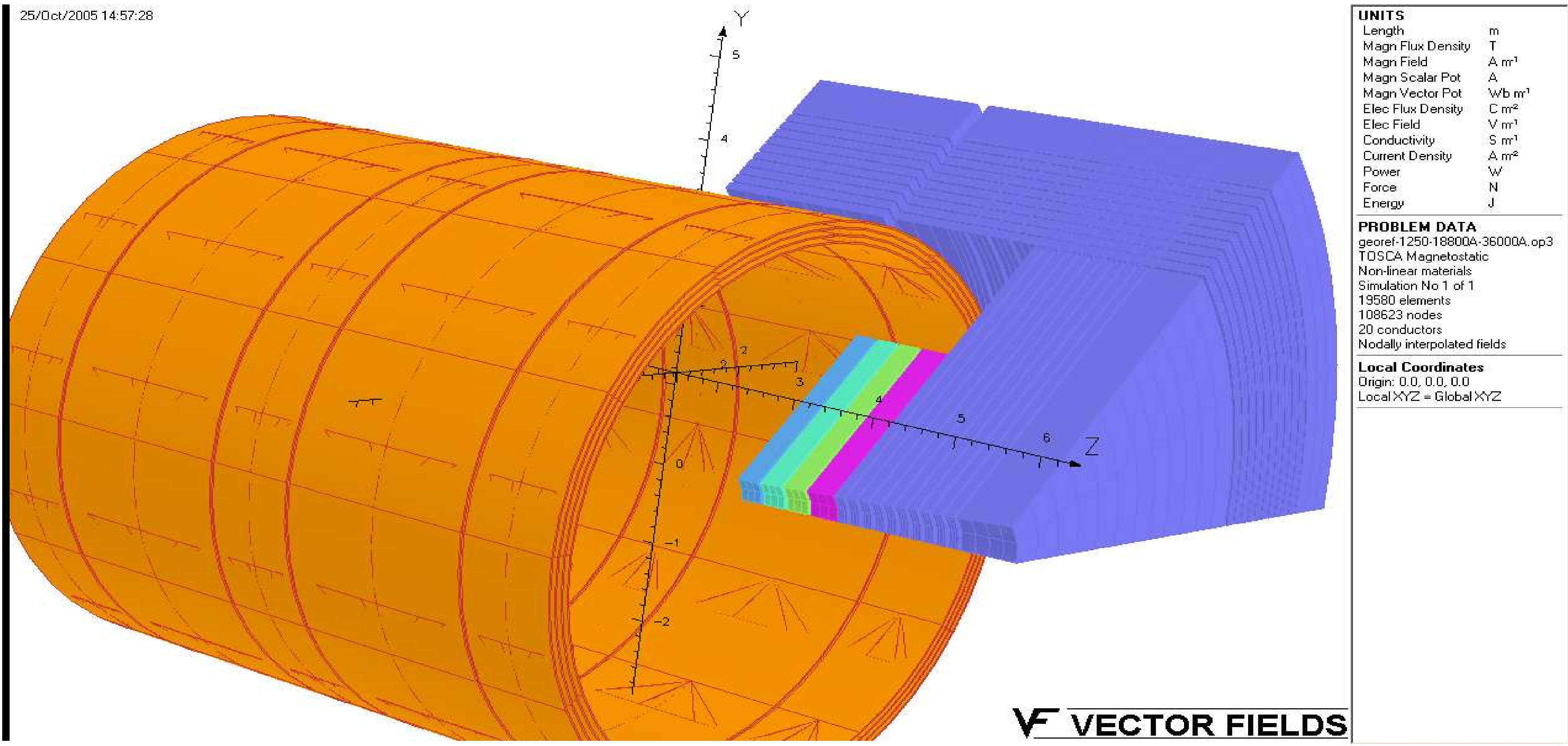

LDC V2
cm
600.
500.
400.
300.
200.
100.
0.
Return yoke
Coil
HCAL
ECAL
TPC
LCAL
BCAL
350.0
220.0
250.0
230.0
226.0
216.0
380.0
0.
100.
200.
300.
400.
500.
600.
cm
HV



LDC V2
cm
600.
500.
400.
300.
200.
100.
0.
Return yoke
Coil
HCAL
ECAL
TPC
LCAL
BCAL
350.0
220.0
250.0
230.0
226.0
216.0
380.0
0.
100.
200.
300.
400.
500.
600.
cm
HV

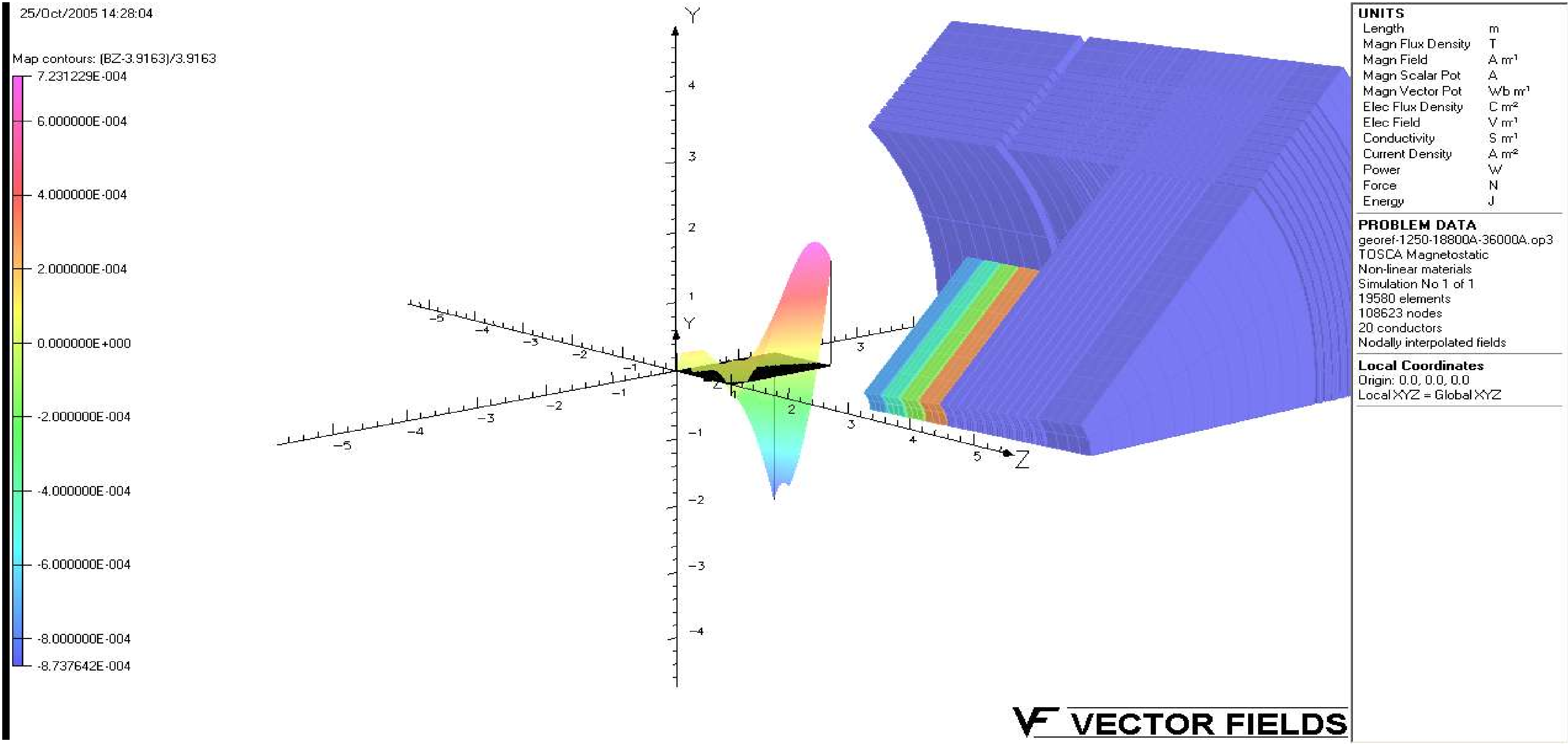
Model being tested

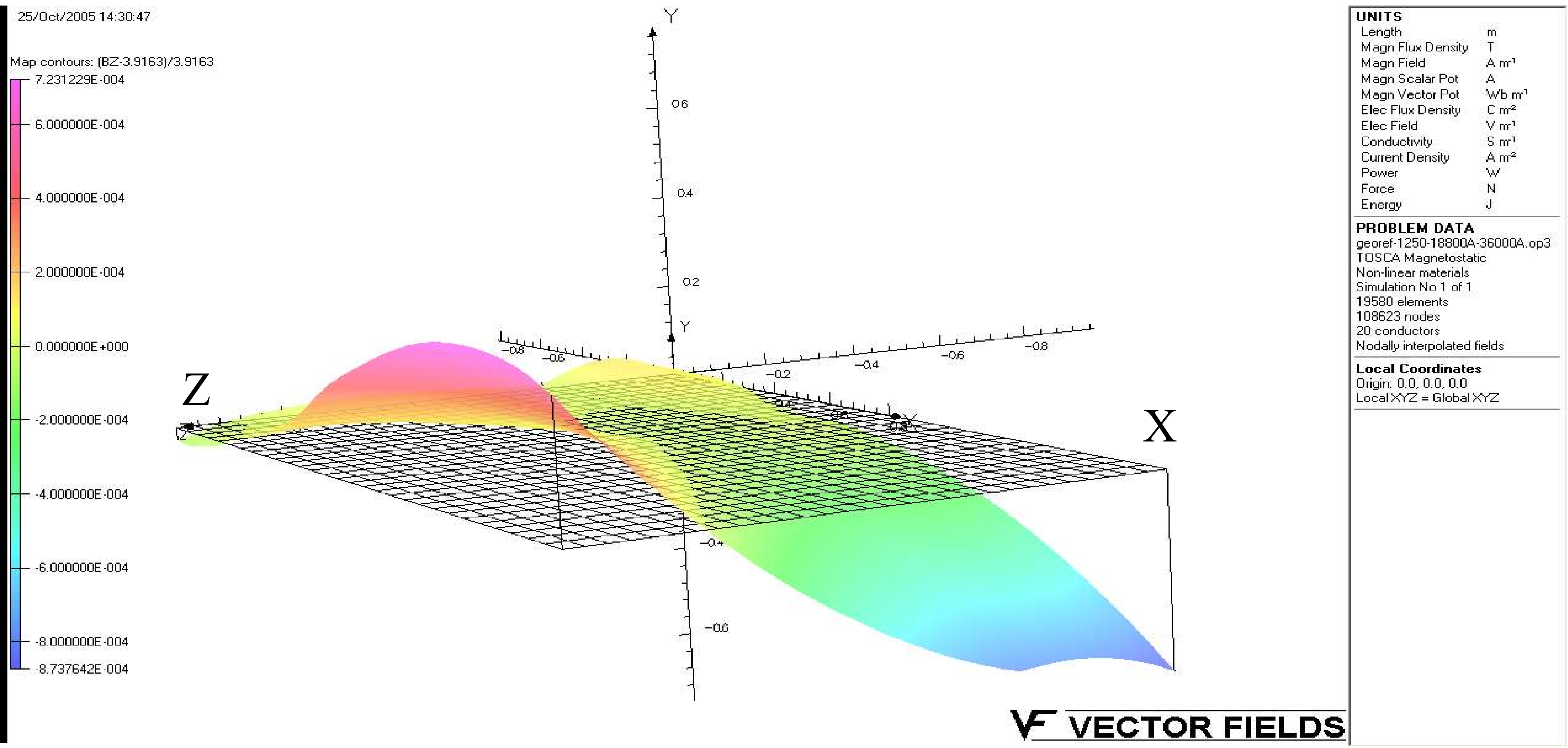
O. Delferrière CEA-Saclay

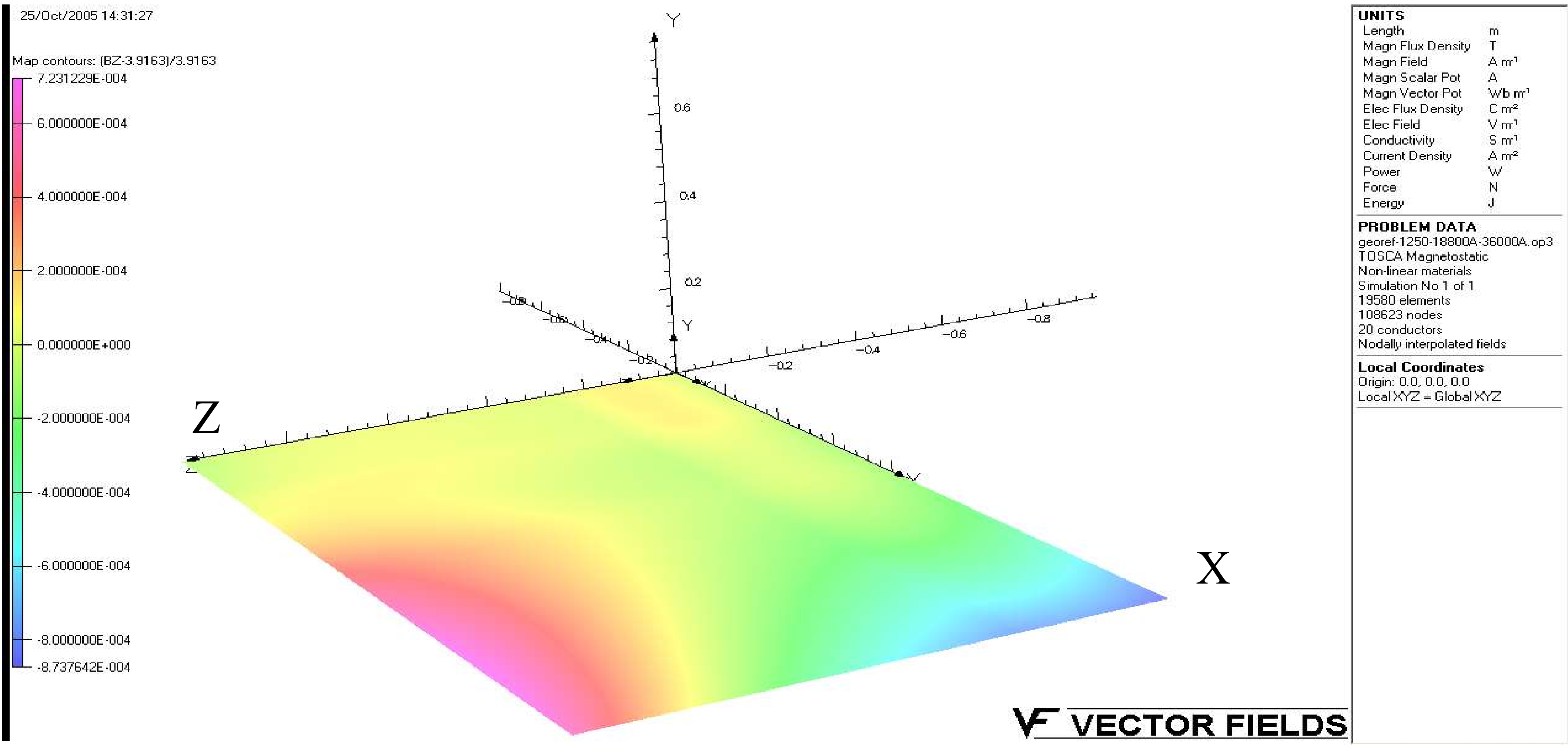


Note: as long as the model is phi symmetric there is no phi field component!

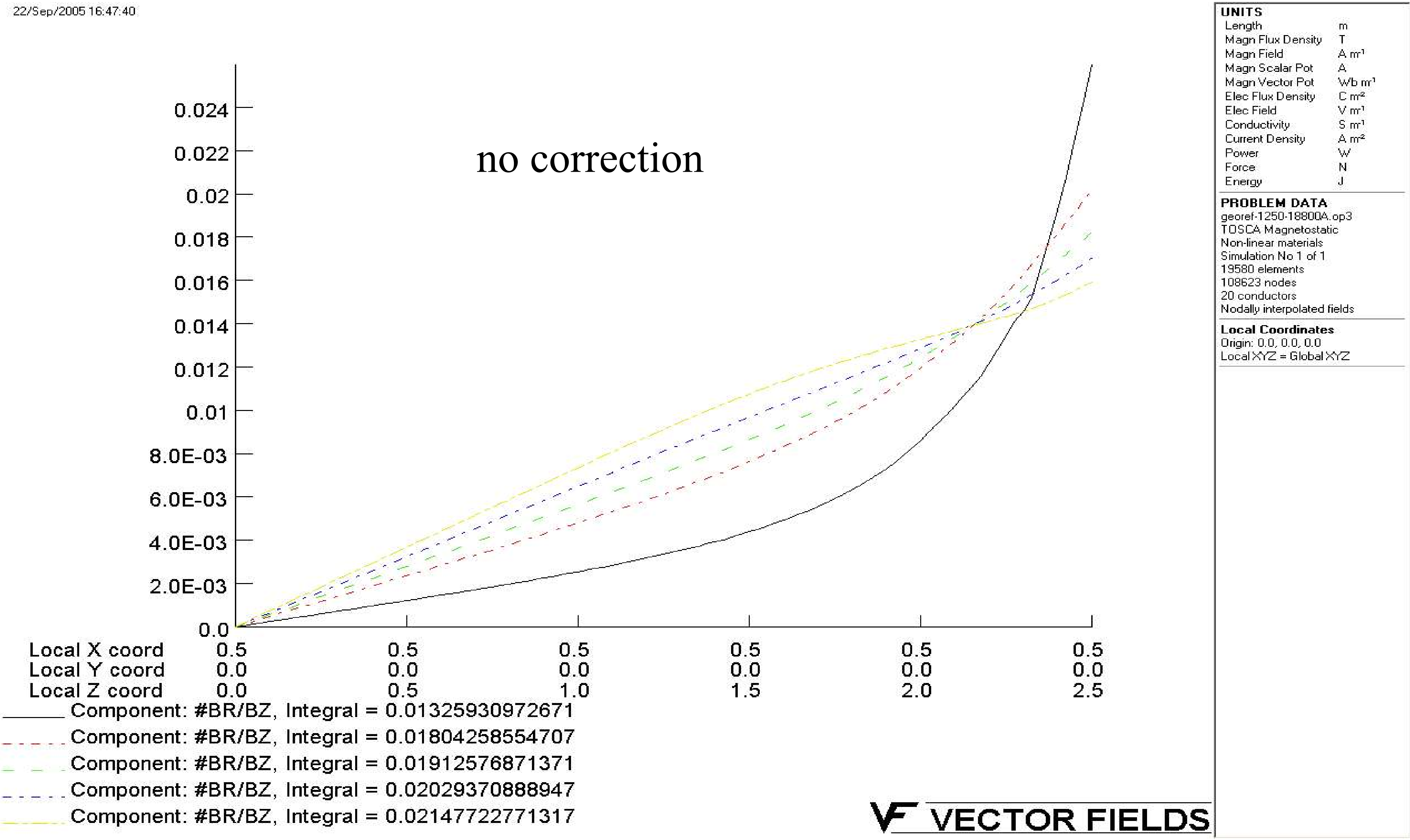
Quality of the field in the central part of the TPC: +- 50 cm

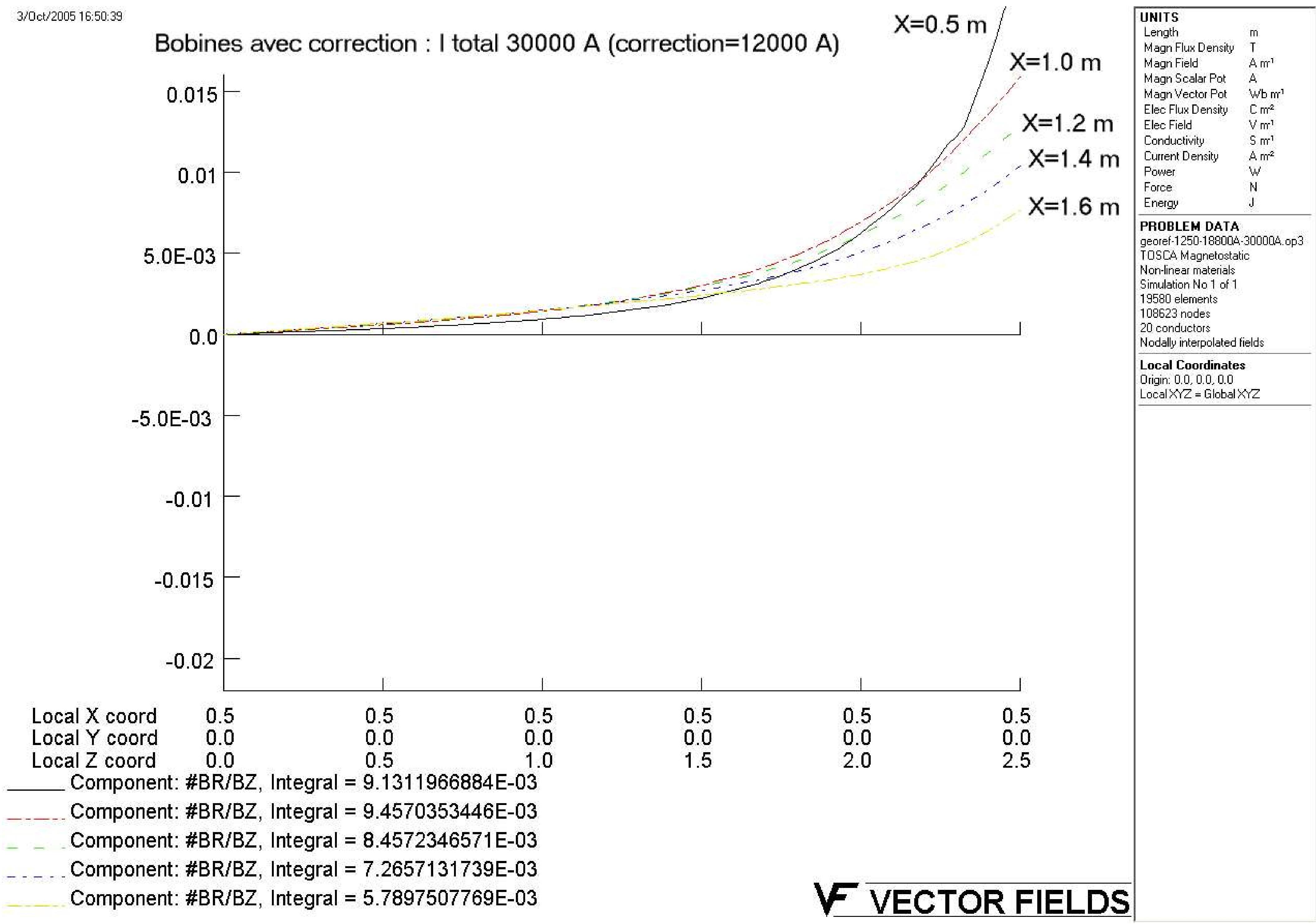



25/Oct/2005 14:30:47
Map contours: (BZ-3.9163)/3.9163
7.231229E-004
6.000000E-004
4.000000E-004
2.000000E-004
0.000000E+000
-2.000000E-004
-4.000000E-004
-6.000000E-004
-8.000000E-004
-8.737642E-004
Y
0.6
0.4
0.2
Y
-0.4
-0.6
Z
X
UNITS
Length m
Magn Flux Density T
Magn Field A m⁻¹
Magn Scalar Pot A
Magn Vector Pot Wb m⁻¹
Elec Flux Density C m⁻²
Elec Field V m⁻¹
Conductivity S m⁻¹
Current Density A m⁻²
Power W
Force N
Energy J
PROBLEM DATA
georef-1250-18800A-36000A.op3
TOSCA Magnetostatic
Non-linear materials
Simulation No 1 of 1
19580 elements
108623 nodes
20 conductors
Nodally interpolated fields
Local Coordinates
Origin: 0.0, 0.0, 0.0
Local XYZ = Global XYZ
VECTOR FIELDS

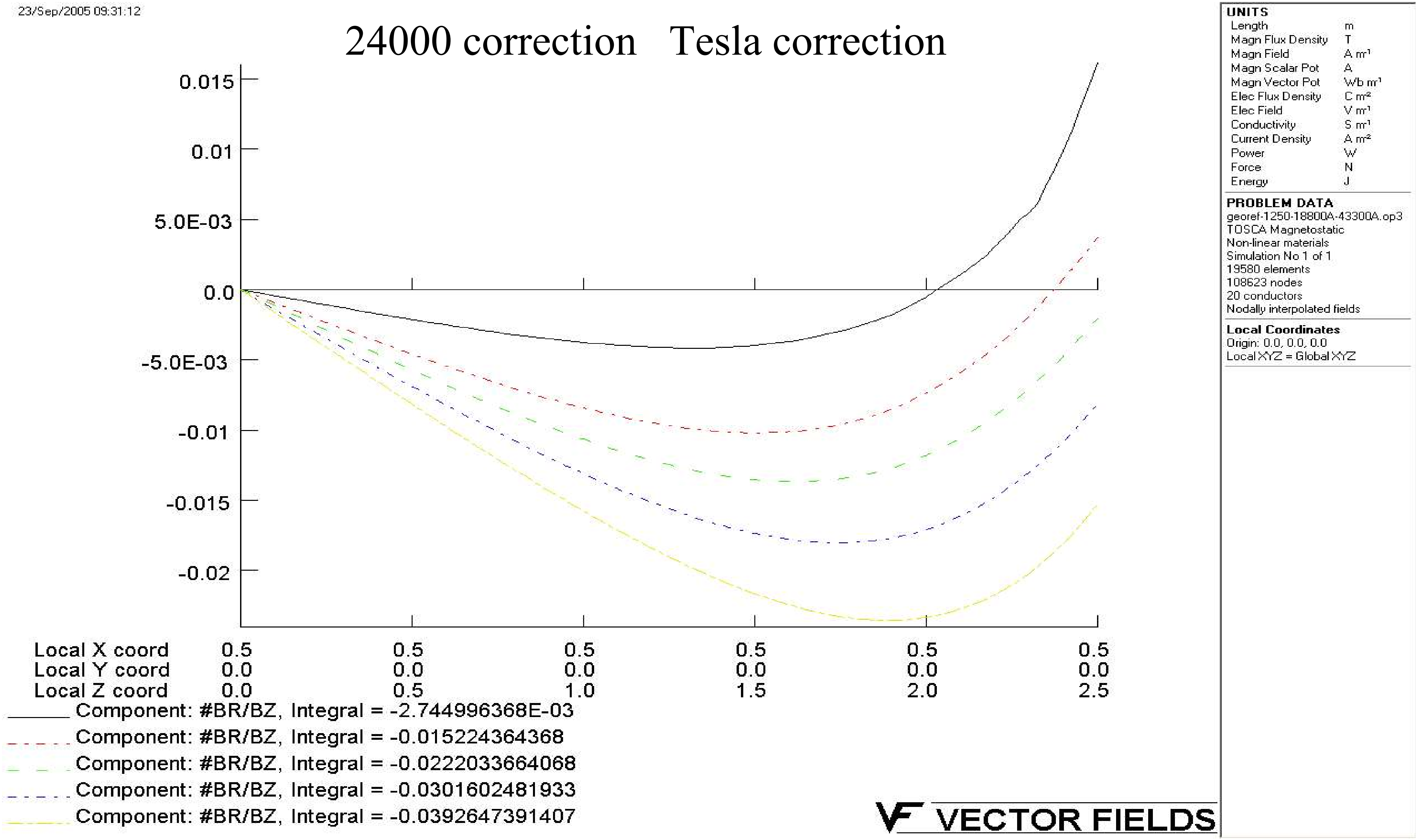

25/Oct/2005 14:31:27
Map contours: (BZ-3.9163)/3.9163
7.231229E-004
6.000000E-004
4.000000E-004
2.000000E-004
0.000000E+000
-2.000000E-004
-4.000000E-004
-6.000000E-004
-8.000000E-004
-8.737642E-004
Y
0.6
0.4
0.2
-0.2
-0.4
-0.6
-0.8
Z
X
UNITS
Length m
Magn Flux Density T
Magn Field A m⁻¹
Magn Scalar Pot A
Magn Vector Pot Wb m⁻¹
Elec Flux Density C m⁻²
Elec Field V m⁻¹
Conductivity S m⁻¹
Current Density A m⁻²
Power W
Force N
Energy J
PROBLEM DATA
georef-1250-18800A-36000A.op3
TOSCA Magnetostatic
Non-linear materials
Simulation No 1 of 1
19580 elements
108623 nodes
20 conductors
Nodally interpolated fields
Local Coordinates
Origin: 0.0, 0.0, 0.0
Local XYZ = Global XYZ
VECTOR FIELDS

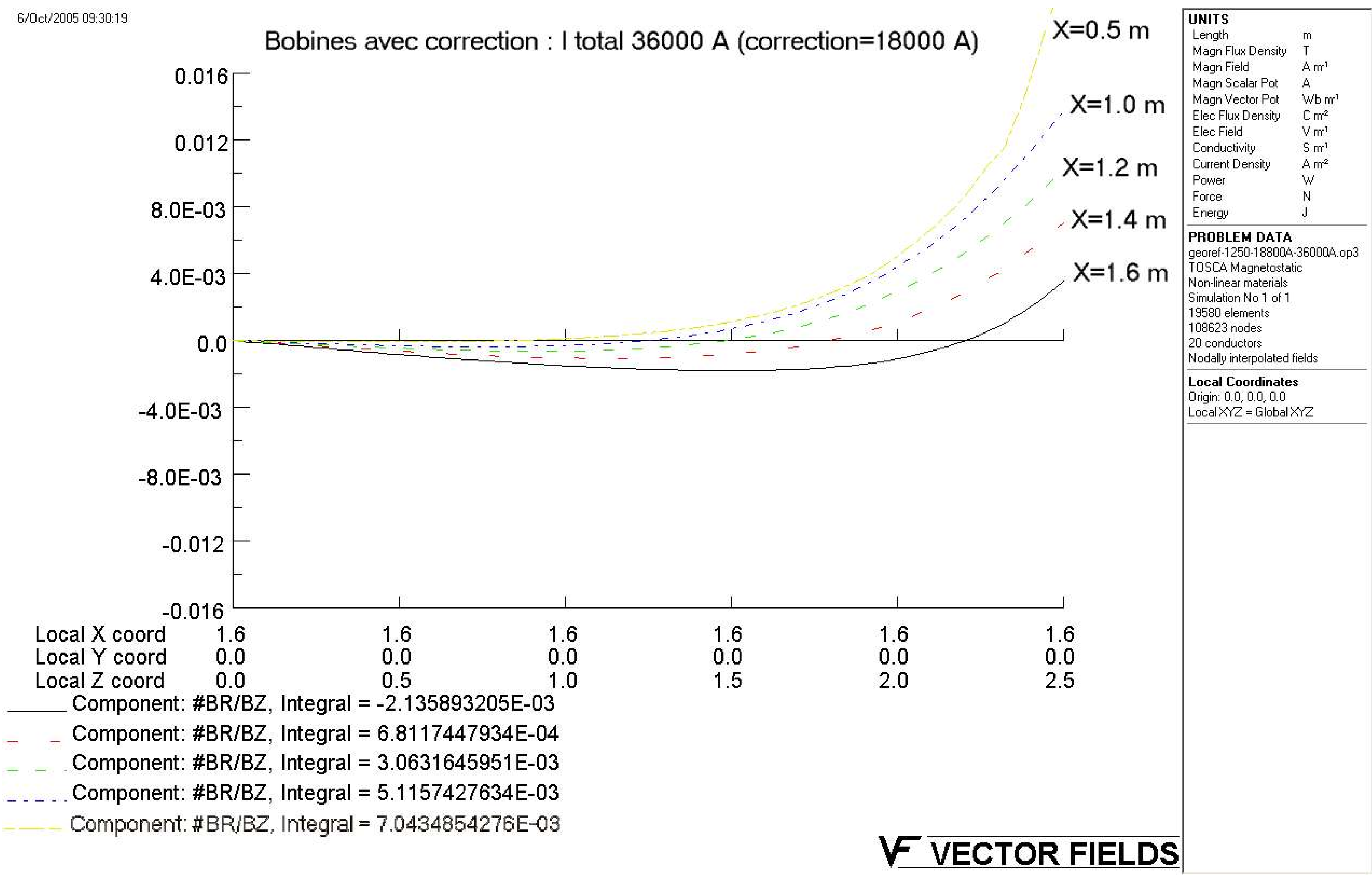
Optimising the radial field integral playing with correcting currents



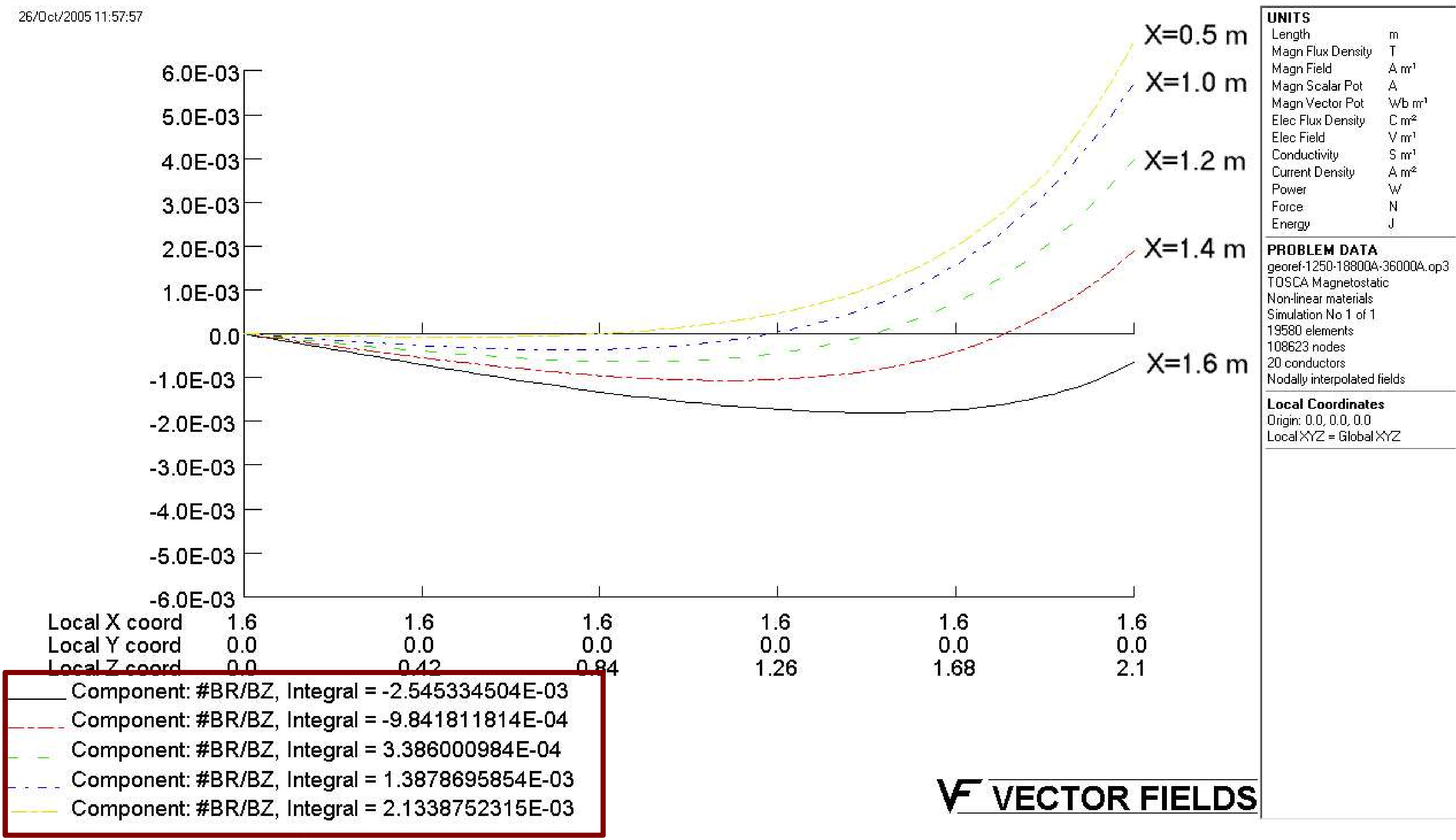

3/Oct/2005 16:50:39
Bobines avec correction : I total 30000 A (correction=12000 A)
X=0.5 m
X=1.0 m
X=1.2 m
X=1.4 m
X=1.6 m
0.015
0.01
5.0E-03
0.0
-5.0E-03
-0.01
-0.015
-0.02
Local X coord 0.5 0.5 0.5 0.5 0.5 0.5
Local Y coord 0.0 0.0 0.0 0.0 0.0 0.0
Local Z coord 0.0 0.5 1.0 1.5 2.0 2.5
Component: #BR/BZ, Integral = 9.1311966884E-03
Component: #BR/BZ, Integral = 9.4570353446E-03
Component: #BR/BZ, Integral = 8.4572346571E-03
Component: #BR/BZ, Integral = 7.2657131739E-03
Component: #BR/BZ, Integral = 5.7897507769E-03
VECTOR FIELDS
UNITS
Length m
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 m⁻¹
Current Density A m⁻²
Power W
Force N
Energy J
PROBLEM DATA
georef-1250-18800A-30000A.op3
TOSCA Magnetostatic
Non-linear materials
Simulation No 1 of 1
19580 elements
108623 nodes
20 conductors
Nodally interpolated fields
Local Coordinates
Origin: 0.0, 0.0, 0.0
Local XYZ = Global XYZ

24000 correction   Tesla correction




6/Oct/2005 09:30:19
Bobines avec correction : I total 36000 A (correction=18000 A)
0.016
0.012
8.0E-03
4.0E-03
0.0
-4.0E-03
-8.0E-03
-0.012
-0.016
X=0.5 m
X=1.0 m
X=1.2 m
X=1.4 m
X=1.6 m
Local X coord 1.6 1.6 1.6 1.6 1.6 1.6
Local Y coord 0.0 0.0 0.0 0.0 0.0 0.0
Local Z coord 0.0 0.5 1.0 1.5 2.0 2.5
Component: #BR/BZ, Integral = -2.135893205E-03
Component: #BR/BZ, Integral = 6.8117447934E-04
Component: #BR/BZ, Integral = 3.0631645951E-03
Component: #BR/BZ, Integral = 5.1157427634E-03
Component: #BR/BZ, Integral = 7.0434854276E-03
UNITS
Length m
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 m⁻¹
Current Density A m⁻²
Power W
Force N
Energy J
PROBLEM DATA
georef-1250-18800A-36000A.op3
TOSCA Magnetostatic
Non-linear materials
Simulation No 1 of 1
19580 elements
108623 nodes
20 conductors
Nodally interpolated fields
Local Coordinates
Origin: 0.0, 0.0, 0.0
Local XYZ = Global XYZ
VECTOR FIELDS

About optimal correction for a TPC of 2.1 m length



It looks really possible to have a field quality good enough for TPC with this shortened coil.

Or not really worse than with the long one.

Need more work in particular for the stray field BUT this needs to have a better idea about our baseline detector