

Magnetic field calculations for PANDA magnets

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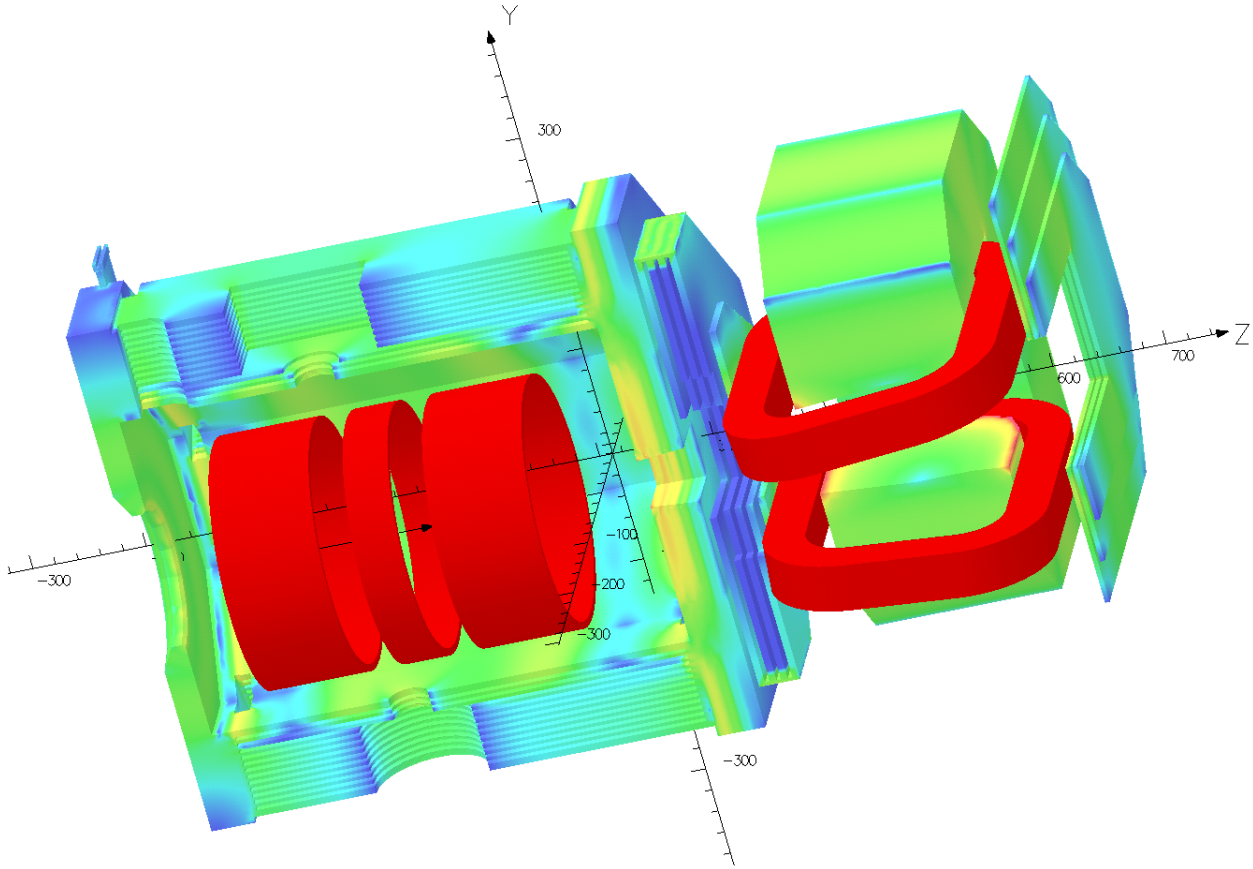
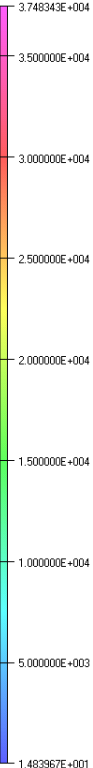
Contents

- Coupling between the solenoid and dipole magnet.
- Stray fields at the TOF and RICH regions.
- Rotating patch analysis of the dipole and solenoid fields.
- Considerations for magnetic field mapping.
- Conclusions.

3D TOSCA model for solenoid and dipole magnets

23/Nov/2009 12:11:55

Surface contours: BMOD



UNITS	
Length	cm
Magn Flux	gauss
Density	
Magn Field	oersted
Magn Scalar	oersted
Pot	cm
Magn Vector	gauss
Pot	cm
Elec Flux	C cm ²
Density	
Elec Field	V cm ¹
Conductivity	S cm ¹
Current	A cm ²
Density	
Power	W
Force	N
Energy	J
Mass	g

PROBLEM DATA
 sole_dipole_threelayers:
 TOSCA Magnetostatic
 Nonlinear materials
 Simulation No 1 of 1
 12550047 elements
 16853167 nodes
 4 conductors
 Nodally interpolated fields
 Activated in global coordinates
 Reflection in YZ plane (X field=0)

Field Point Local Coordinates
 Local = Global

FIELD EVALUATIONS
 Circle CIRCLE 10
 (integral)
 r=30.0, e=0.0,

Field map in the vertical plane

30/Nov/2009 16:11:48

Map contours: BMOD

2.970249E+004

2.500000E+004

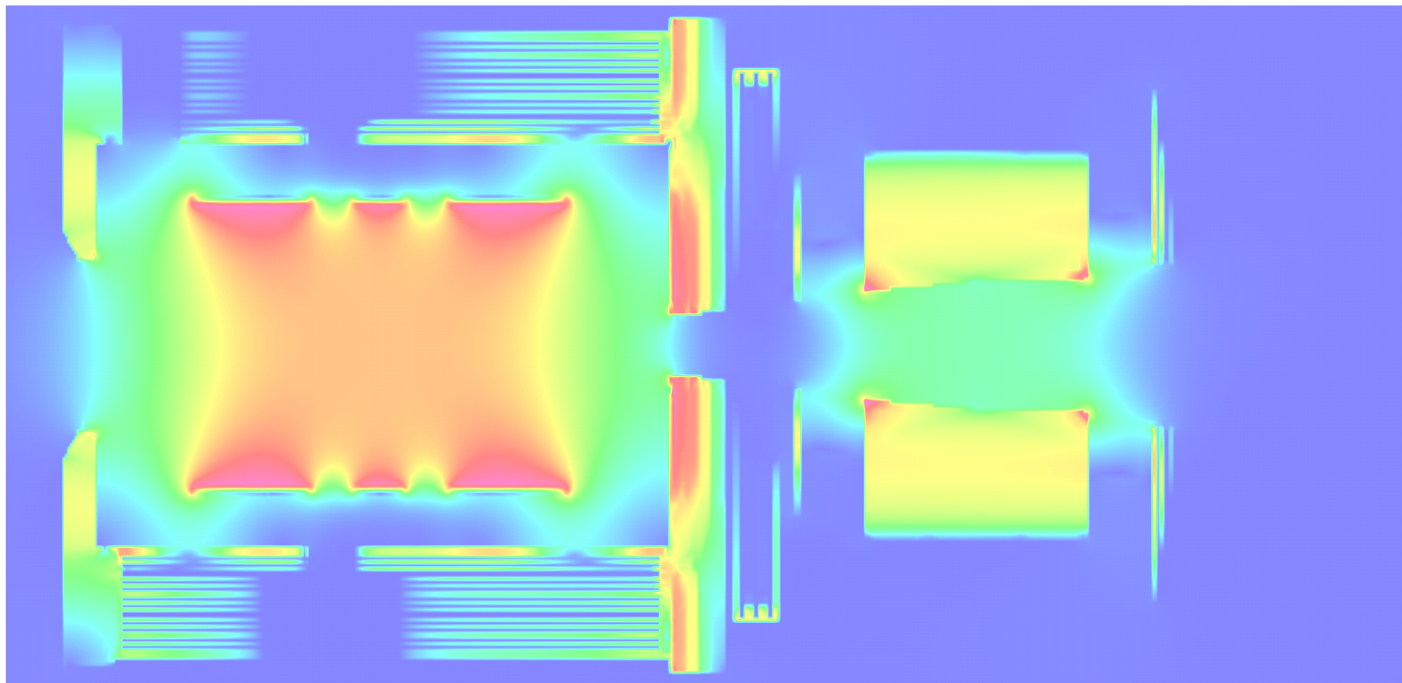
2.000000E+004

1.500000E+004

1.000000E+004

5.000000E+003

1.583107E+001



UNITS

Length	cm
Magn Flux Density	gauss
Magn Field	oersted
Magn Scalar Pot	gauss cm
Magn Vector Pot	oersted cm
Elec Flux Density	C cm ²
Elec Field	V cm ⁻¹
Conductivity	S cm ⁻¹
Current Density	A cm ²
Power	W
Force	N
Energy	J
Mass	g

PROBLEM DATA

sole_dipole_threelayers231009.op3
TOSCA Magnetostatic
Nonlinear materials:
Simulation No 1 of 1
12550047 elements
16853167 nodes
4 conductors
Nodally interpolated fields
Activated in global coordinates

Field Point Local Coordinates

Local = Global

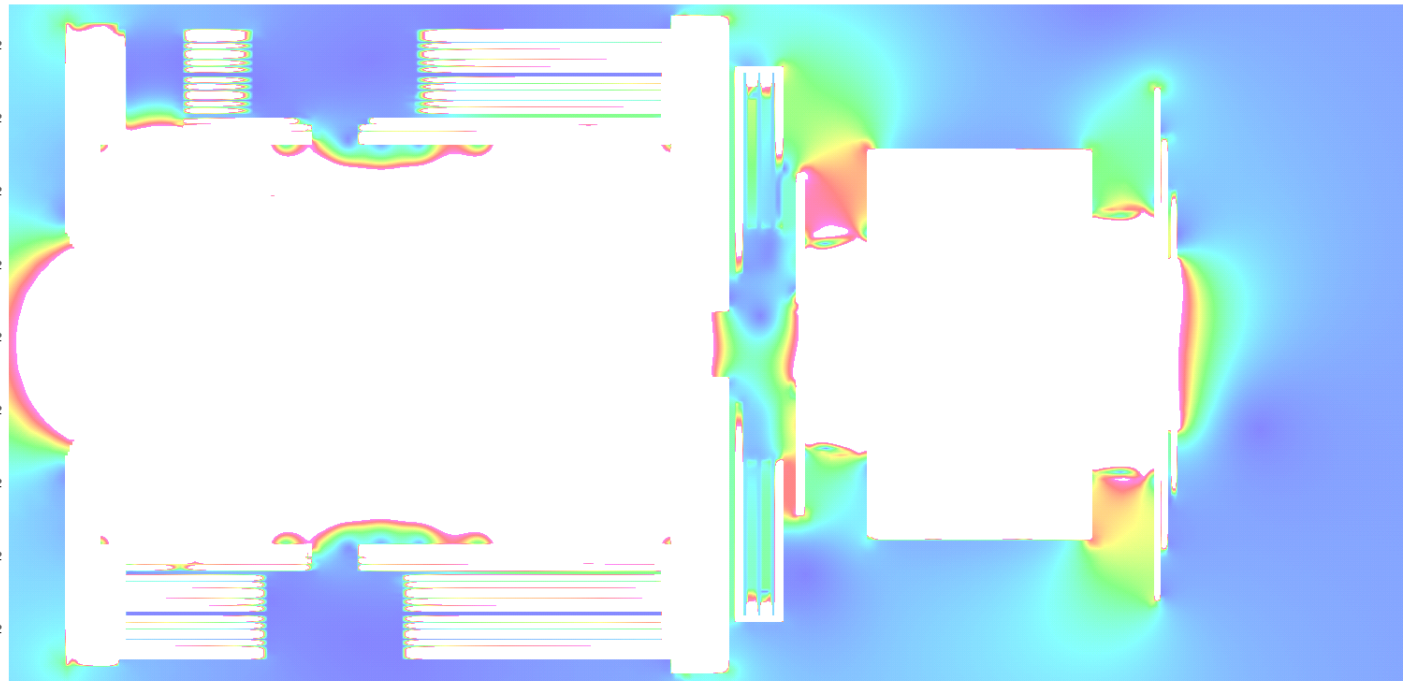
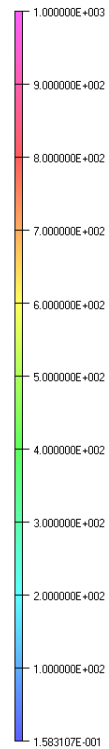
FIELD EVALUATIONS

Cartesian	CARTESIAN	200x600	Cartesian
(nodal)			
x=0.0, y=250.0 to 250.0, z=-240.0 to 800.0			

Field map in the vertical plane

30/Nov/2009 16:15:50

Map contours: BMDD



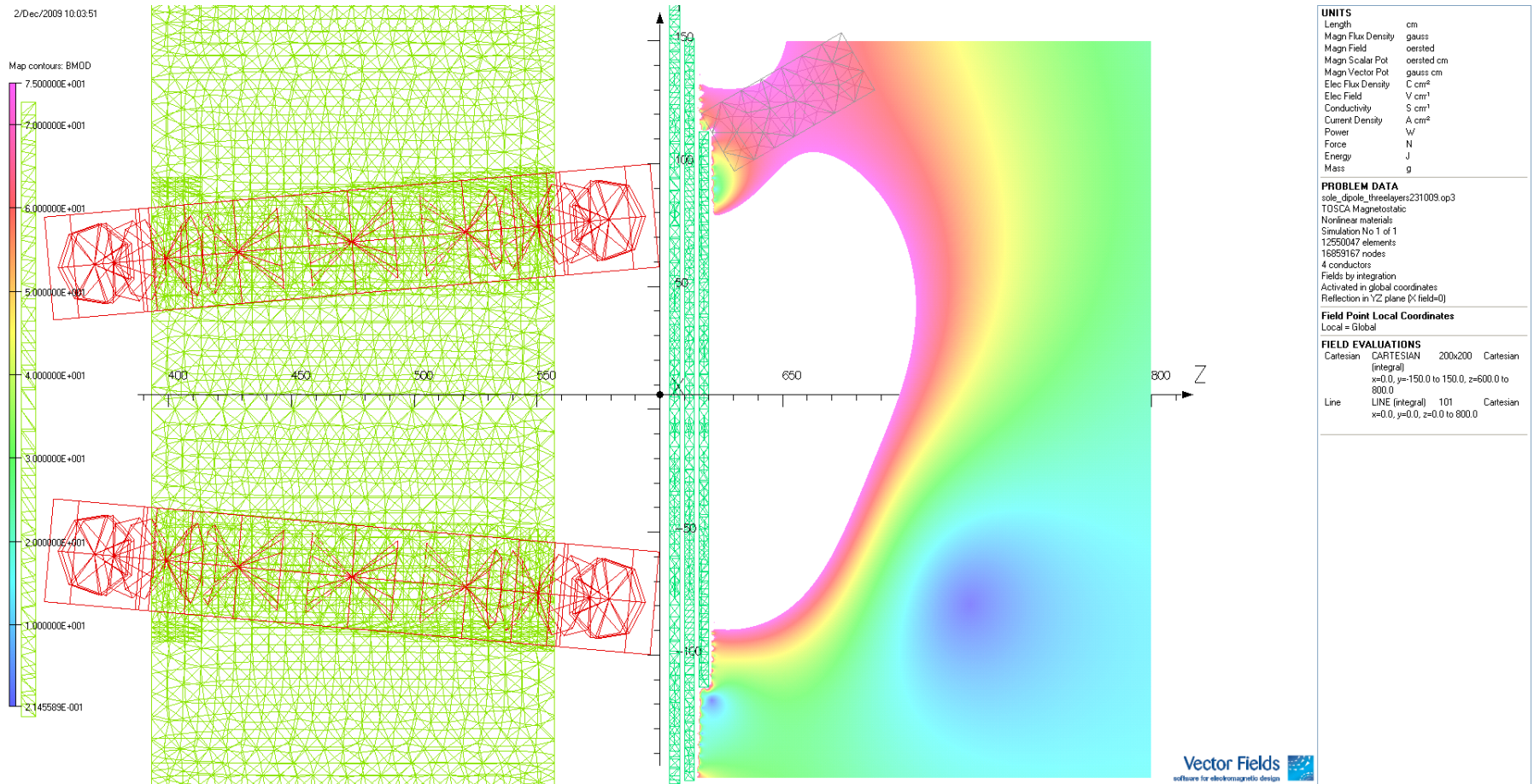
UNITS	
Length	cm
Magn Flux Density	gauss
Magn Field	oersted
Magn Scalar Pot	oersted cm
Magn Vector Pot	gauss cm
Elec Flux Density	C cm ²
Elec Field	V cm ⁻¹
Conductivity	S cm ⁻¹
Current Density	A cm ²
Power	W
Force	N
Energy	J
Mass	g

PROBLEM DATA
sole_dpole_threelayers231009.cp3
TOSCA Magnetostatic
Nonlinear materials
Simulation No 1 of 1
12550047 elements
1659167 nodes
4 conductors
Nodally interpolated fields
Activated in global coordinates

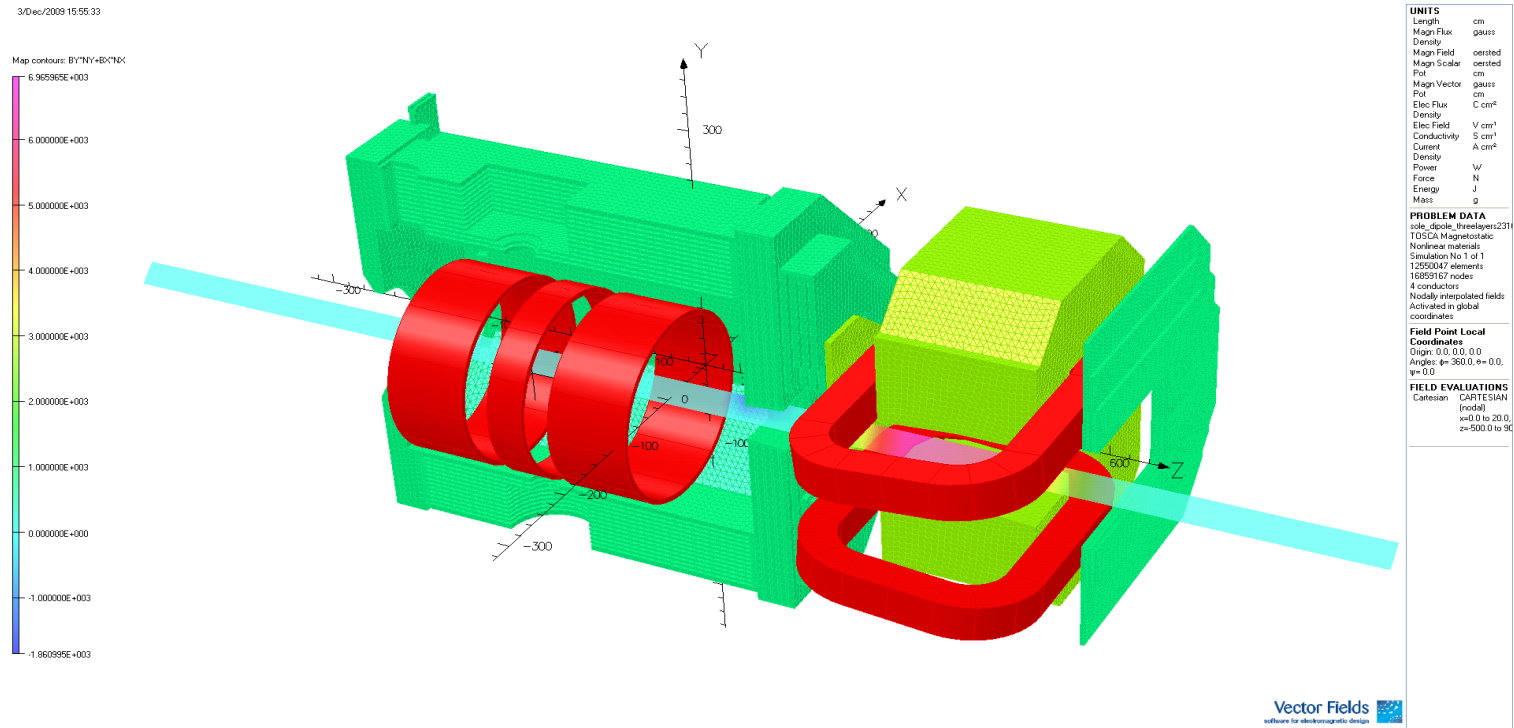
Field Point Local Coordinates
Local = Global

FIELD EVALUATIONS
Cartesian CARTESIAN 200x600 Cartesian
(nodal)
x=0.0, y=-250.0 to 250.0, z=-240.0 to 800.0

The effects of solenoid field on the stray fields at TOF and RICH regions

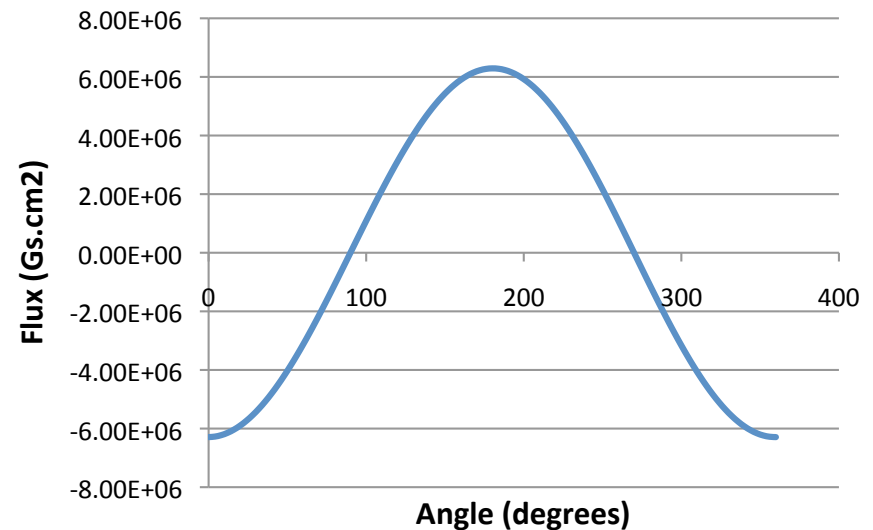


Rotating patch analysis of Solenoid and dipole magnets

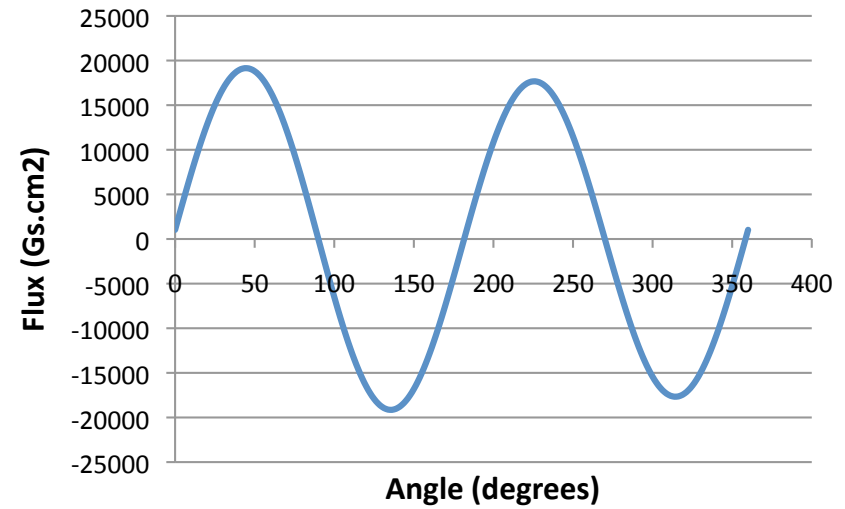
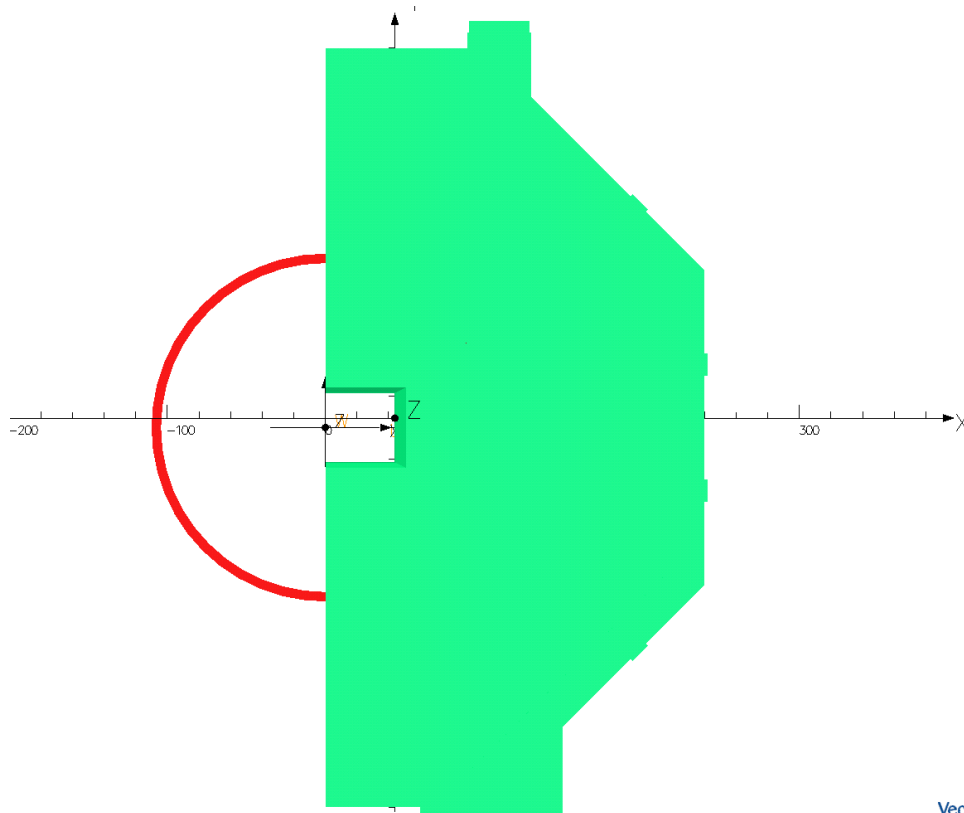


Order	Sine term	Cosine term	Amplitude	Phase
n	A _n	B _n		
0	0	-3.11E-05	3.11E-05	179.999995
1	1.48E-05	-6.29E+06	6.29E+06	-179.999995
2	19132	-1.98E-05	19132	-89.99999755
3	-2.22E-05	131.56	131.56	9.65E-06
4	-25.86	2.20E-05	25.86	89.99994873
5	-6.84E-06	0.314	0.314	1.25E-03
6	-0.109	-1.42E-05	0.109	90.00745288
7	3.96E-05	8.60E-04	8.61E-04	-2.636216583
8	7.77E-04	4.68E-05	7.78E-04	-86.55377715
9	-2.63E-05	-4.48E-04	4.48E-04	176.6395333

Table 1 Fourier coefficients for solenoid and dipole system



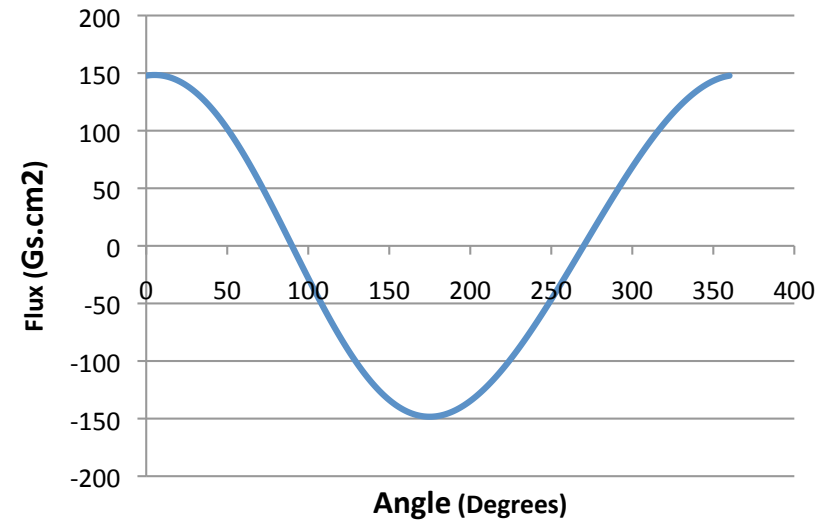
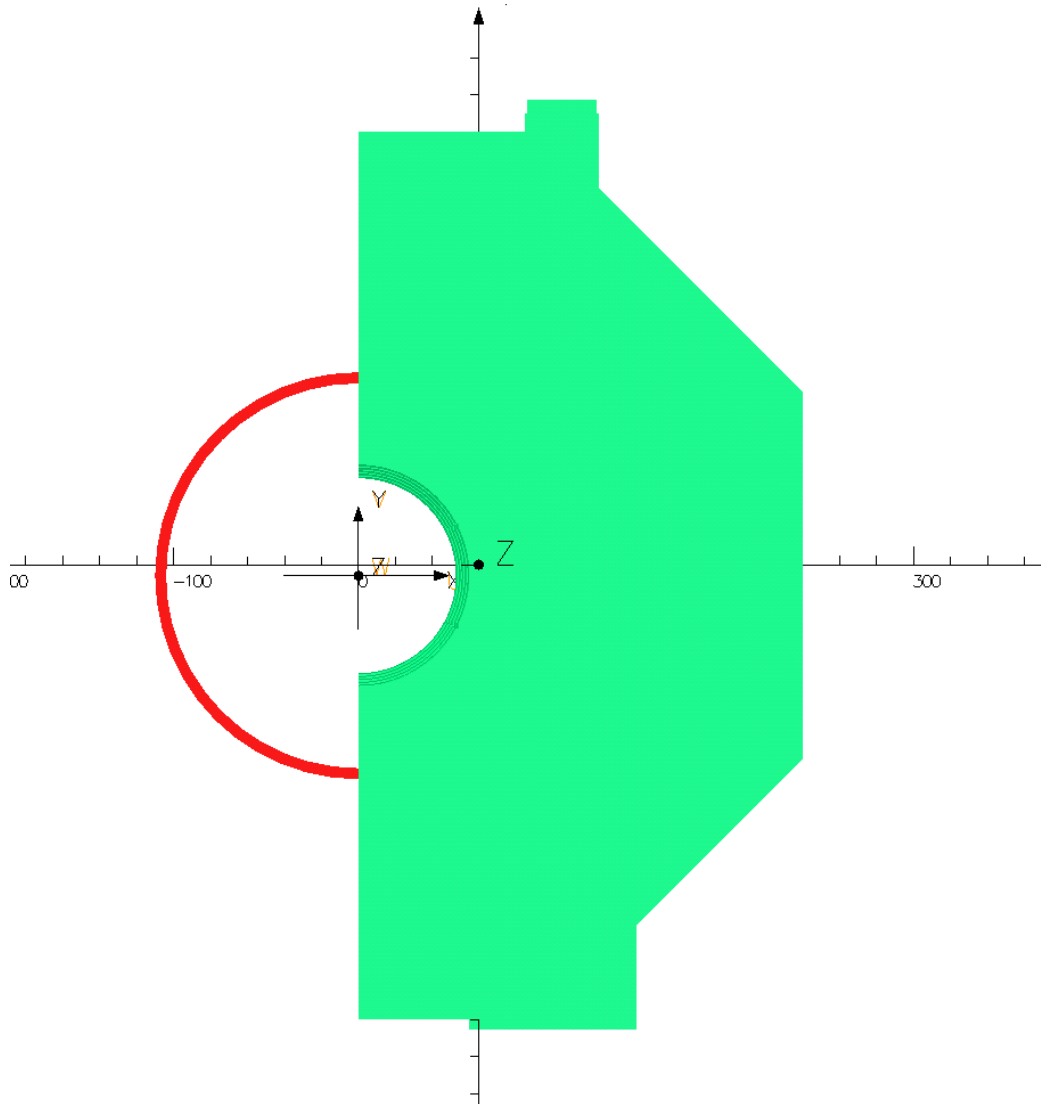
Solenoid with rectangular aperture



Order	Sine term	Cosin term	Amplitude	Phase
n	A _n	B _n		
0	0	0	0	0
1	0	1036.45	1036.45	0
2	18404	0	18404	-90
3	0	-7.79	7.79	-180
4	-22.08	0	22.08	90
5	0	0.057	0.057	0
6	-0.077	0	0.077	90
7	0	2.01E-04	2.01E-04	0
8	4.67E-04	0	4.67E-04	-90
9	0	-1.33E-05	1.33E-05	180

Table 2 Fourier coefficients for solenoid with rectangular aperture

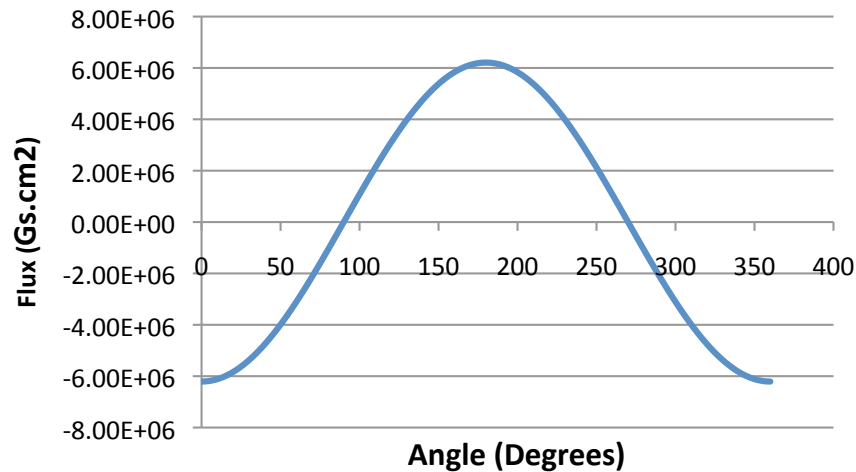
Solenoid with circular aperture



Order	Sine term	Cosine term	Amplitude	Phase
n	A _n	B _n		
0	0	0		0
1	0	147.96	147.96	0
2	6.61	0	6.61	-90
3	0	-0.1999	0.1999	-180
4	6.17E-04	0	6.17E-04	90
5	0	-2.05E-03	2.05E-03	180
6	-3.59E-04	0	3.59E-04	90
7	0	-6.56E-07	6.56E-07	-180
8	0	0	0	90
9	0	-1.52E-08	1.52E-08	180

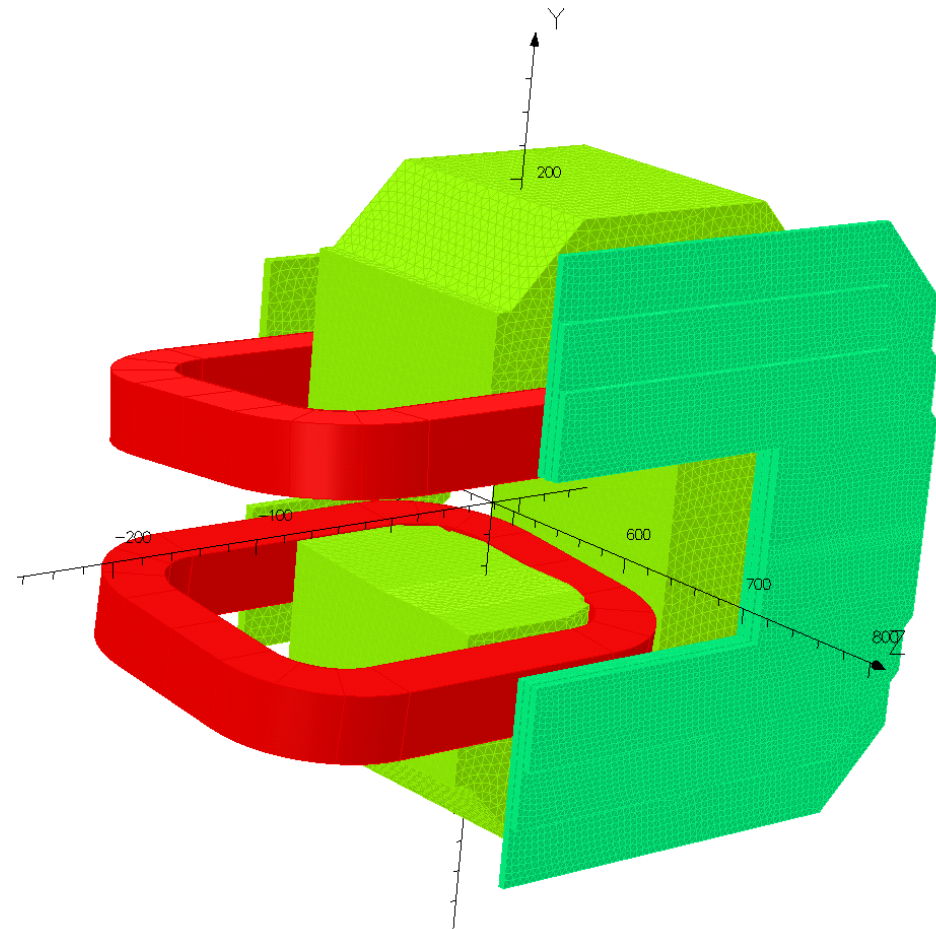
Table 3 Fourier coefficients for solenoid with circular aperture

Dipole magnet



Order	Sine term	Cosine term	Amplitude	Phase
n	A _n	B _n		
0	0	-1.87E-05	1.87E-05	179.999995
1	0	-6.21E+06	6.21E+06	179.999995
2	-1.86	-2.88E-06	1.86	90.00008586
3	1.56E-05	385.84	385.84	-2.32E-06
4	0.015	-3.50E-05	0.015	-90.13257553
5	1.68E-05	0.145	0.145	-6.61E-03
6	-3.74E-05	-5.12E-06	3.78E-05	97.79624719
7	1.02E-05	1.22E-04	1.22E-04	-4.798012432
8	2.17E-05	1.88E-05	2.87E-05	-49.20257092
9	8.24E-06	4.65E-05	4.72E-05	-10.05719905

Table 4 Fourier coefficients for dipole magnet



Considerations for field mapping

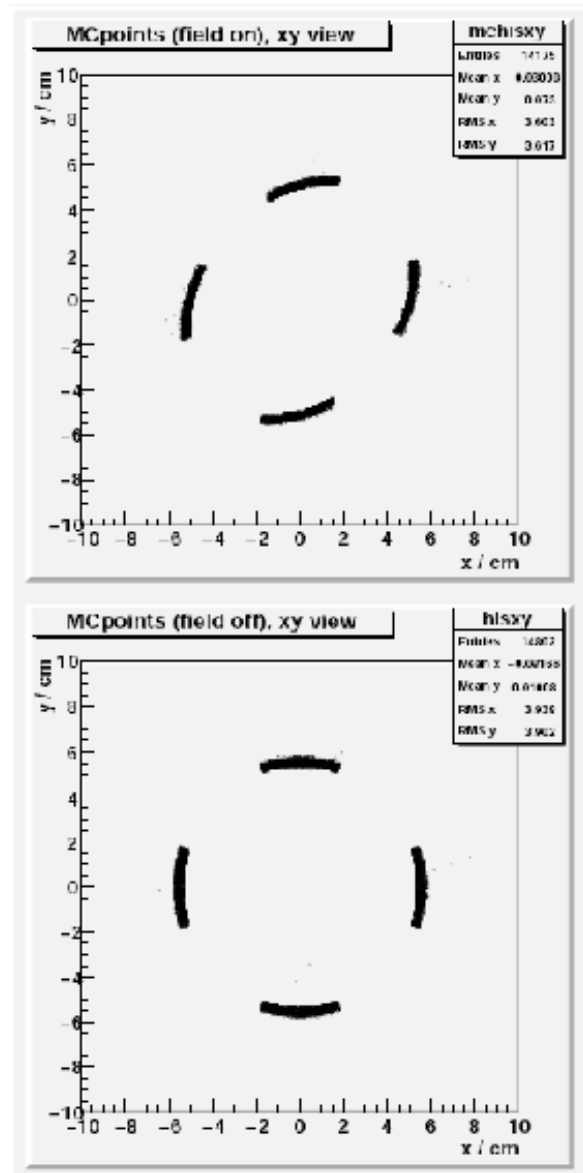
- The accuracy requirements for field mapping.
- The reproducibility requirements for the magnet field.
- With and without the downstream field clamps and the muon filter, the field distribution will be different. Can these be tolerated?

Conclusions

- The interference between the solenoid magnet and the dipole magnet is small.
- The stray fields at rich and TOF region were affected by the solenoid field.
- Higher order field errors were calculated, a larger quadrupole term was found.
- Considerations for field mapping were discussed.

Solenoid field effect on Luminosity detector

- Left figures show the MC points on the luminosity monitor detector with field and with no field
- Beam particle: anti-proton with 5mrad(emittance from IP) and with momentum of 1.5GeV/c
- This effect would result in the track theta shift of 0.5mrad@1.5GeV/c



HESR bending magnet

Component	First design			Optimized design		
	$0.17T$	$1.0T$	$1.7T$	$0.17T$	$1.0T$	$1.7T$
4-pole	-0.03	0.01	0.10	-0.03	0.01	0.10
6-pole	-4.32	0.72	28.16	-1.57	0.88	3.52
8-pole	0.04	0.06	0.09	0.04	0.06	0.09
10-pole	-1.62	-0.05	6.03	-0.44	0.53	7.96
12-pole	0.01	0.01	0.01	0.01	0.01	0.01
14-pole	-0.06	0.10	0.43	0.03	0.13	0.79
16-pole	$< 10^{-2}$	$< 10^{-2}$	$< 10^{-2}$	$< 10^{-2}$	$< 10^{-2}$	$< 10^{-2}$
18-pole	0.06	0.04	-0.10	0.06	0.05	-0.23
20-pole	$< 10^{-2}$	$< 10^{-2}$	$< 10^{-2}$	$< 10^{-2}$	$< 10^{-2}$	$< 10^{-2}$

Table 5.1: Relative field errors of the bending dipole magnet retrieved from 3D calculations. All values are in units of 10^{-4} . Field errors are upright only. The field of $0.17T$ corresponds to $1.5 GeV/c$, $1.0T$ to $8.9 GeV/c$, and $1.7T$ to $15 GeV/c$ respectively. The reference radius of this multipole expansion is $33 mm$.