Magnetic field calculations for PANDA magnets

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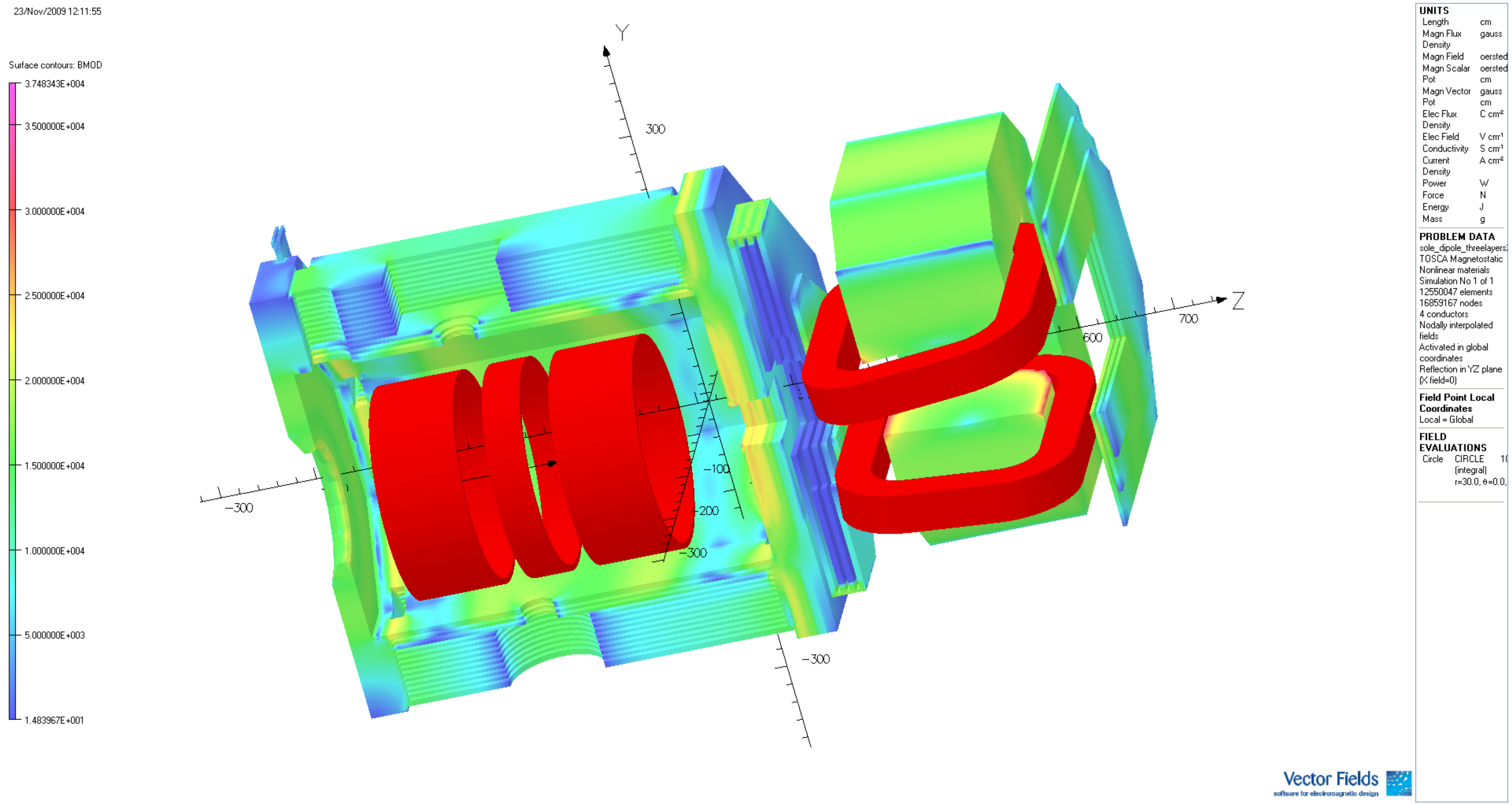
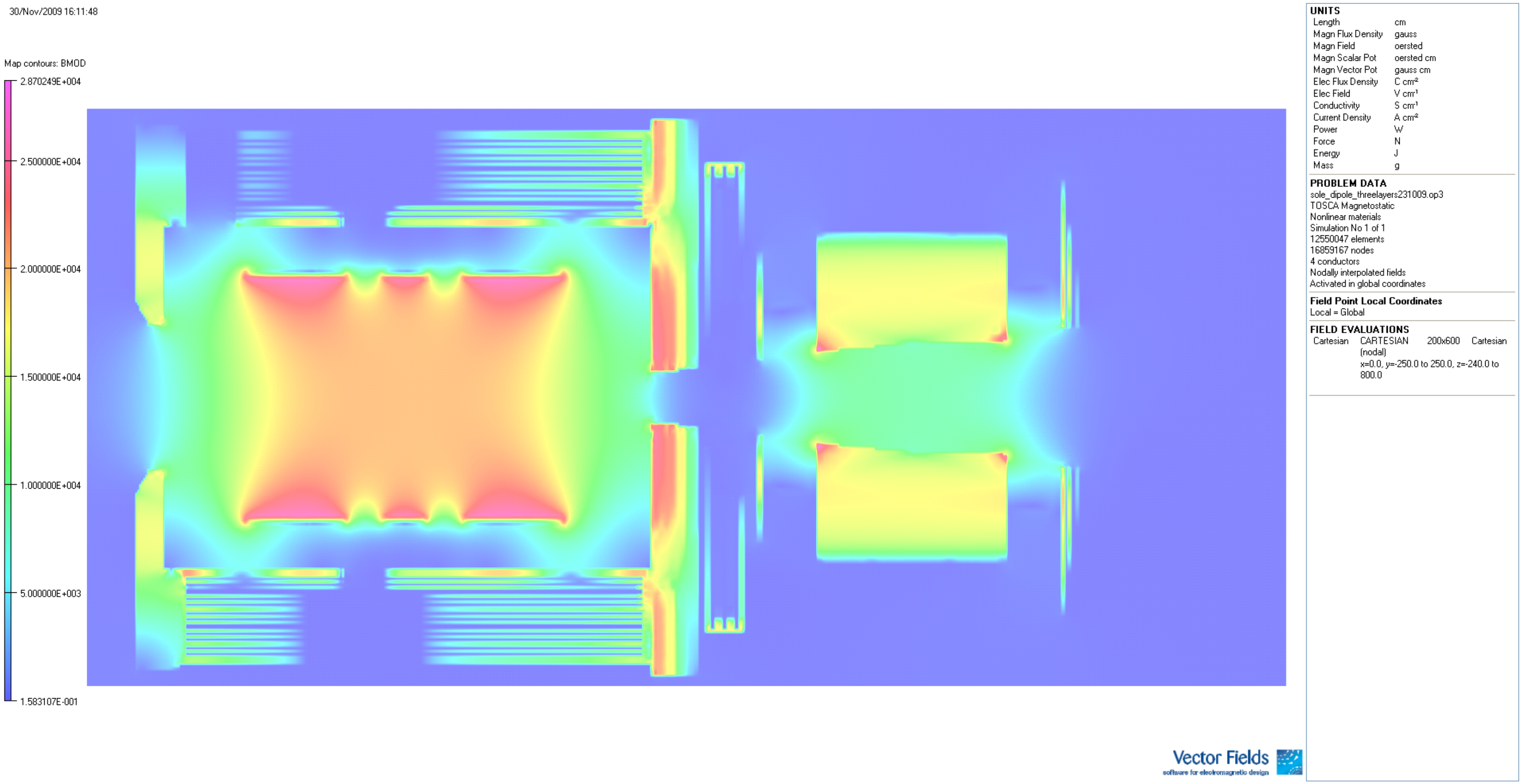
Contents

- 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.

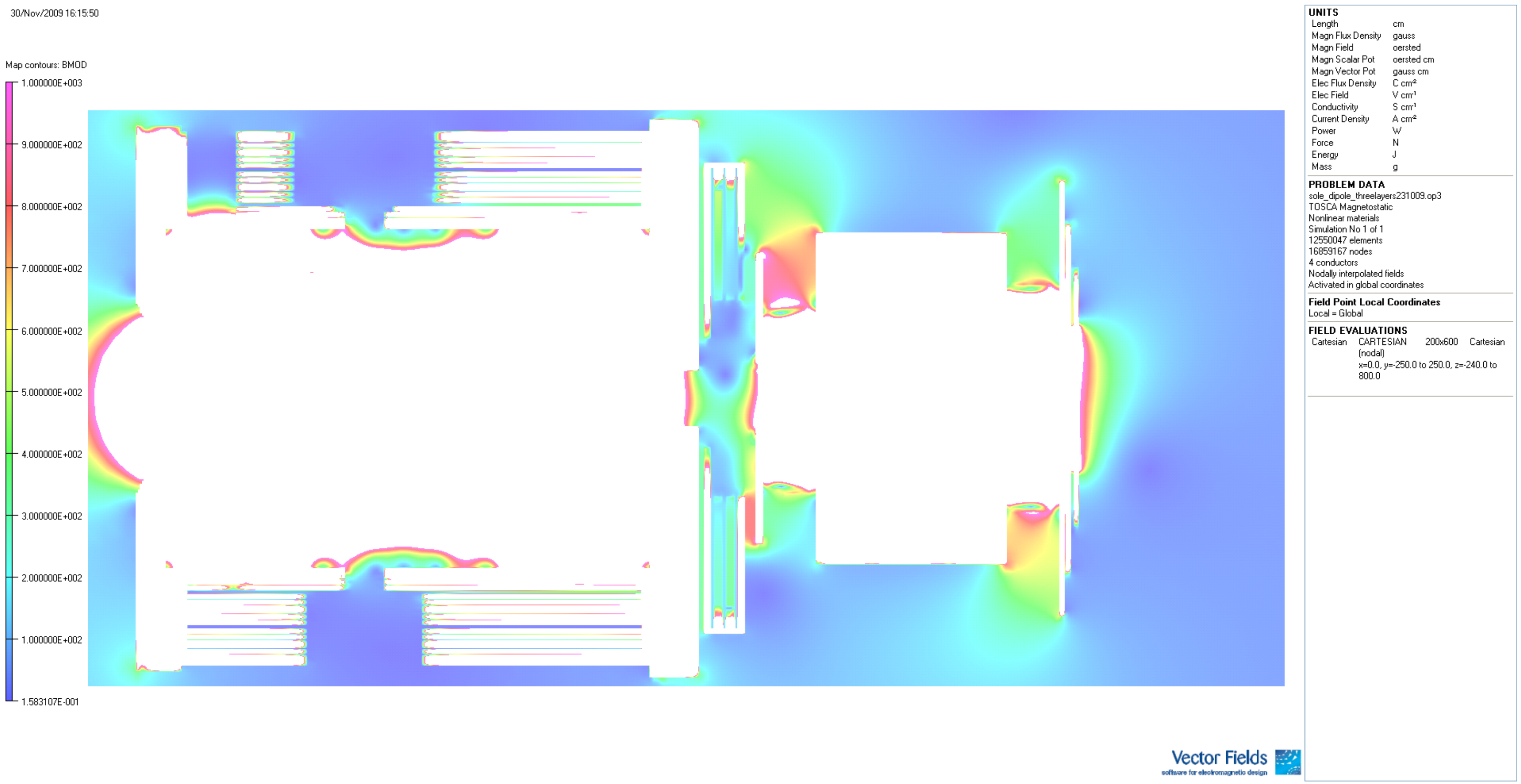
3D TOSCA model for solenoid and dipole magnets



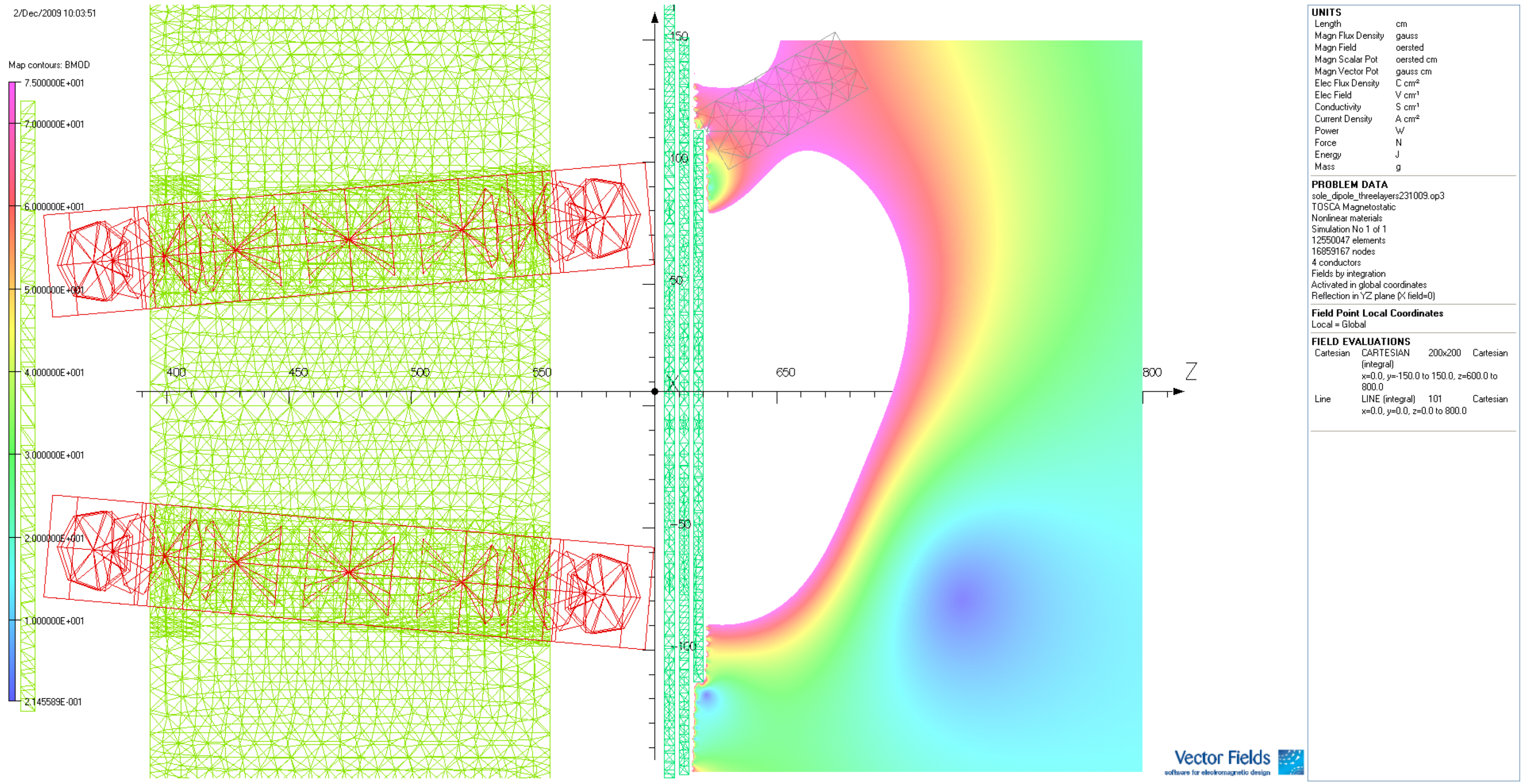
Field map in the vertical plane



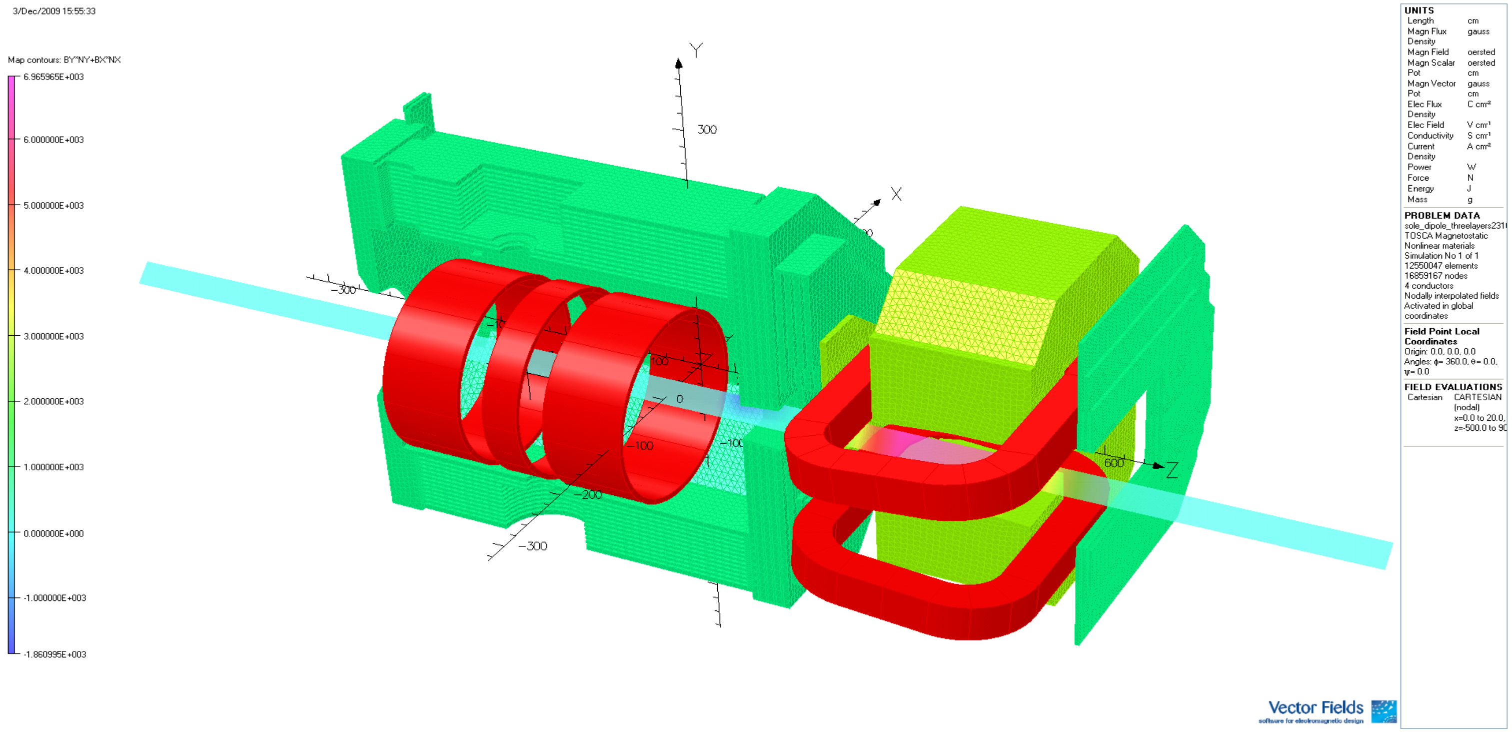
Field map in the vertical plane



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

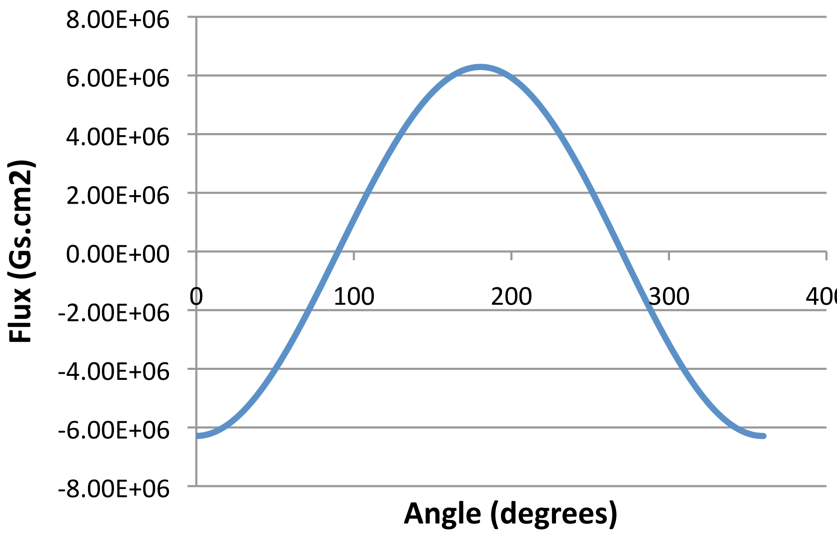


Rotating patch analysis of Solenoid and dipole magnets

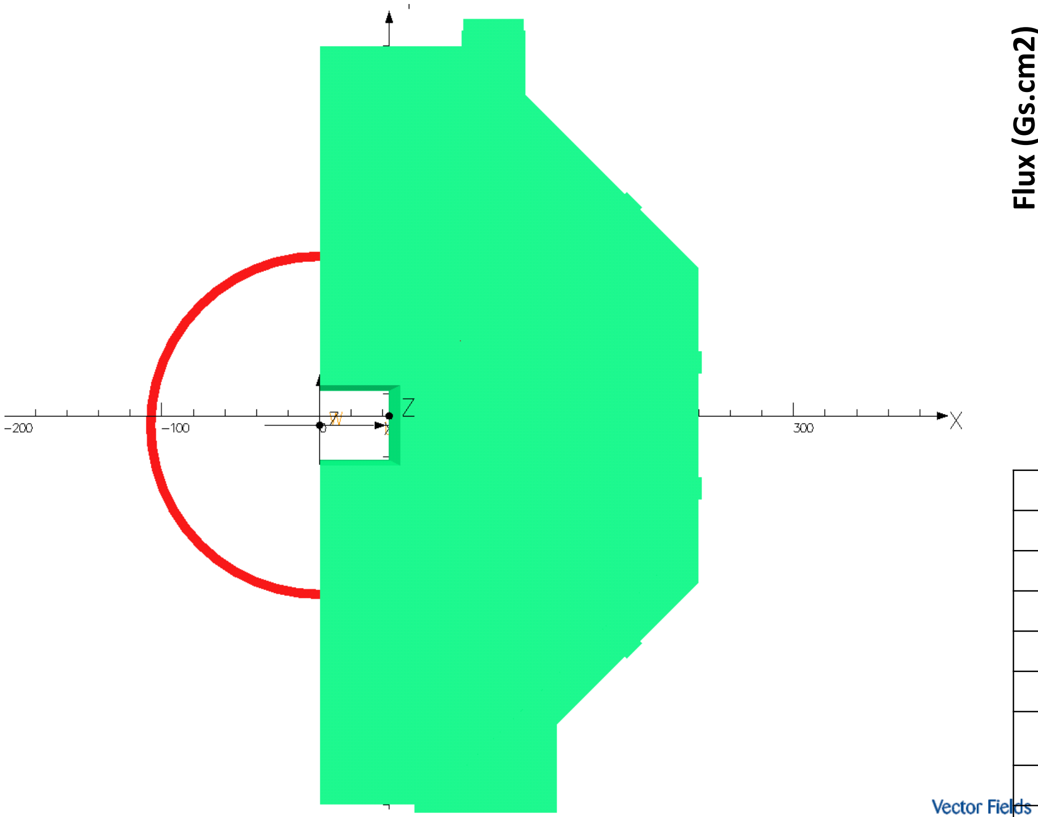


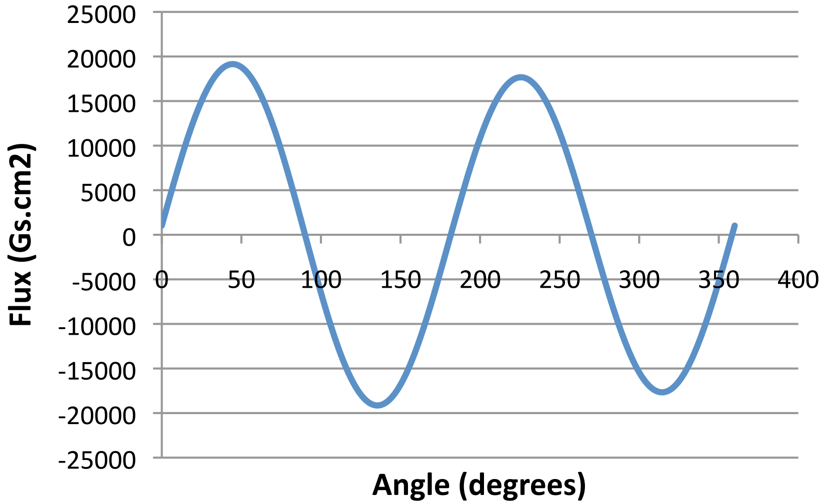
Order	Sine term	Cosine term	Amplitude	Phase
n	A_n	B_n		
0	0	-3.11E-05	3.11E-05	179.999995
1	1.48E-05	-6.29E+06	6.29E+06	-179.999995
2	19132	-1.98E-05	19132	-89.99999755
3	-2.22E-05	131.56	131.56	9.65E-06
4	-25.86	2.20E-05	25.86	89.99994873
5	-6.84E-06	0.314	0.314	1.25E-03
6	-0.109	-1.42E-05	0.109	90.00745288
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

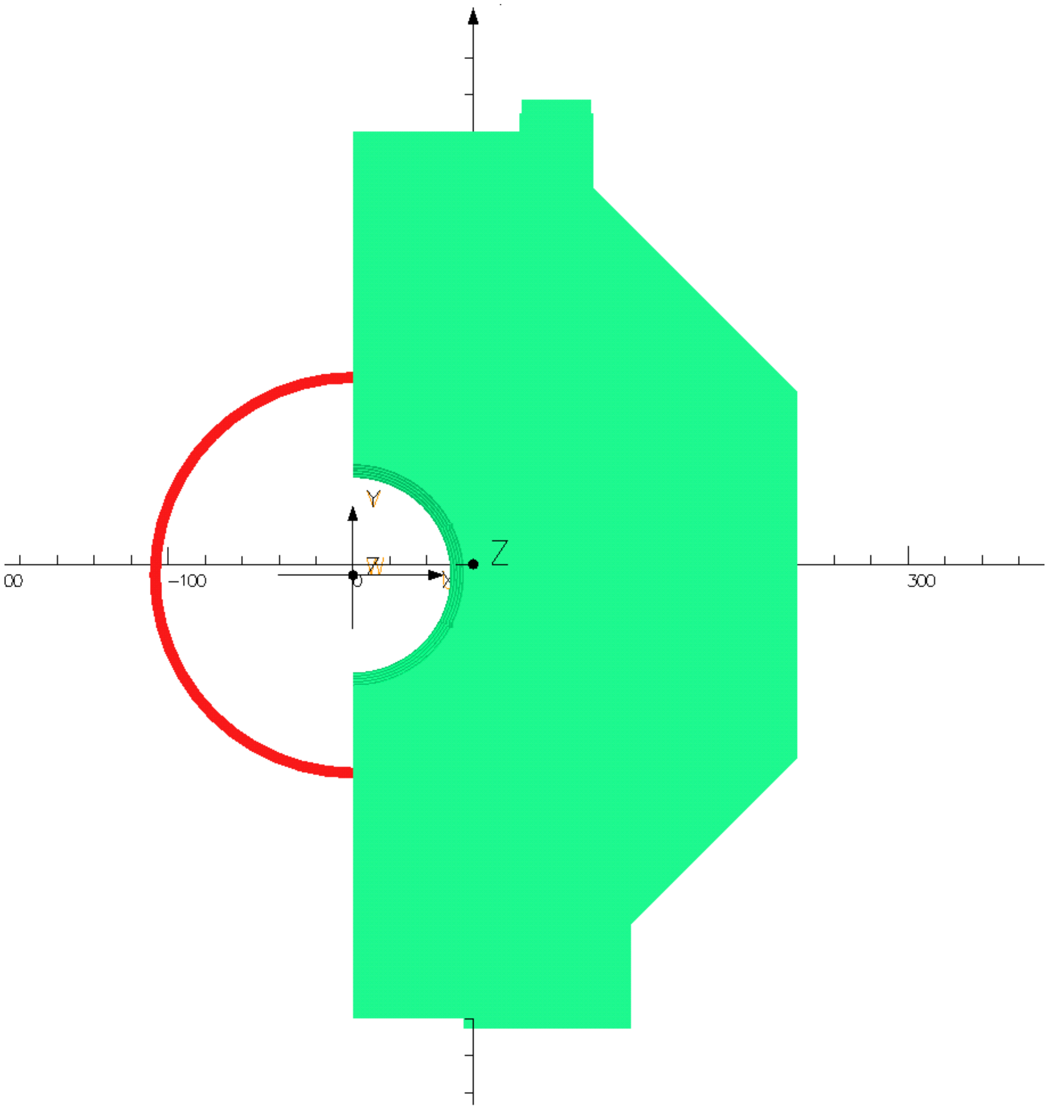


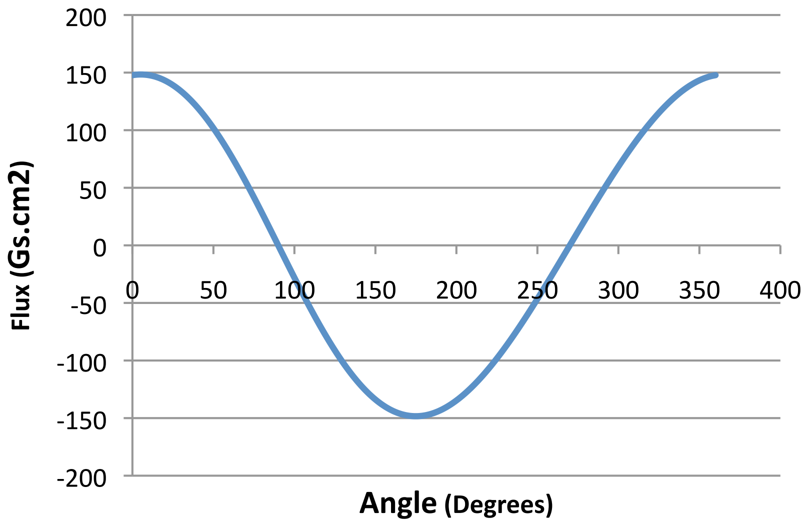


Order	Sine term	Cosinterm	Amplitude	Phase
n	A_n	B_n		
0	0	0	0	0
1	0	1036.45	1036.45	0
2	18404	0	18404	-90
3	0	-7.79	7.79	-180
4	-22.08	0	22.08	90
5	0	0.057	0.057	0
6	-0.077	0	0.077	90
7	0	2.01E-04	2.01E-04	0
8	4.67E-04	0	4.67E-04	-90
9	0	-1.33E-05	1.33E-05	180

Table 2 Fourier coefficients for solenoid with rectangular aperture

Solenoid with circular aperture

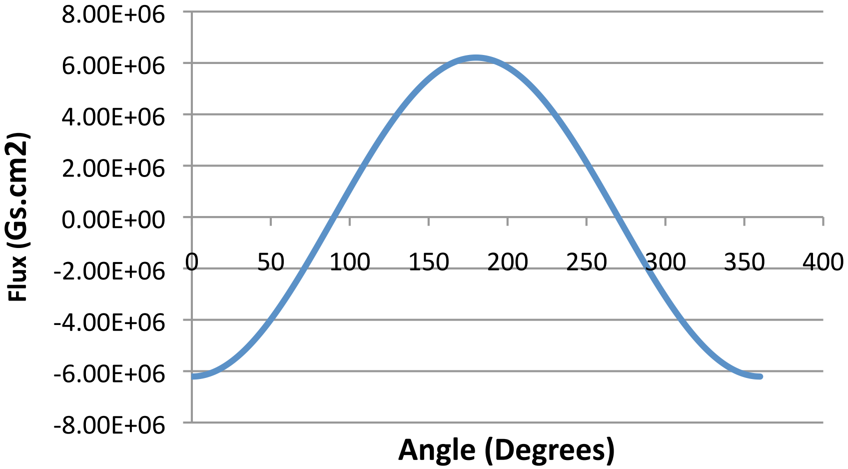




Order	Sine term	Cosine term	Amplitude	Phase
n	A_n	B_n		
0	0	0		0
1	0	147.96	147.96	0
2	6.61	0	6.61	-90
3	0	-0.1999	0.1999	-180
4	6.17E-04	0	6.17E-04	90
5	0	-2.05E-03	2.05E-03	180
6	-3.59E-04	0	3.59E-04	90
7	0	-6.56E-07	6.56E-07	-180
8	0	0	0	90
9	0	-1.52E-08	1.52E-08	180

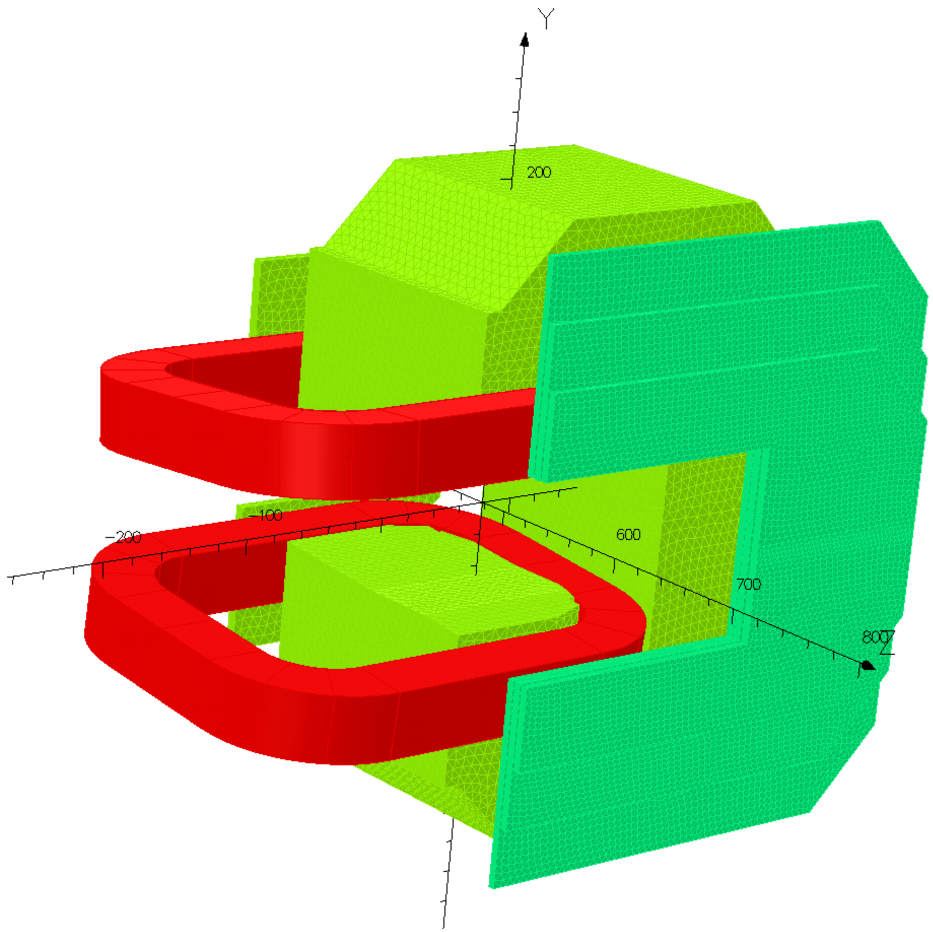
Table 3 Fourier coefficients for solenoid with circular aperture

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

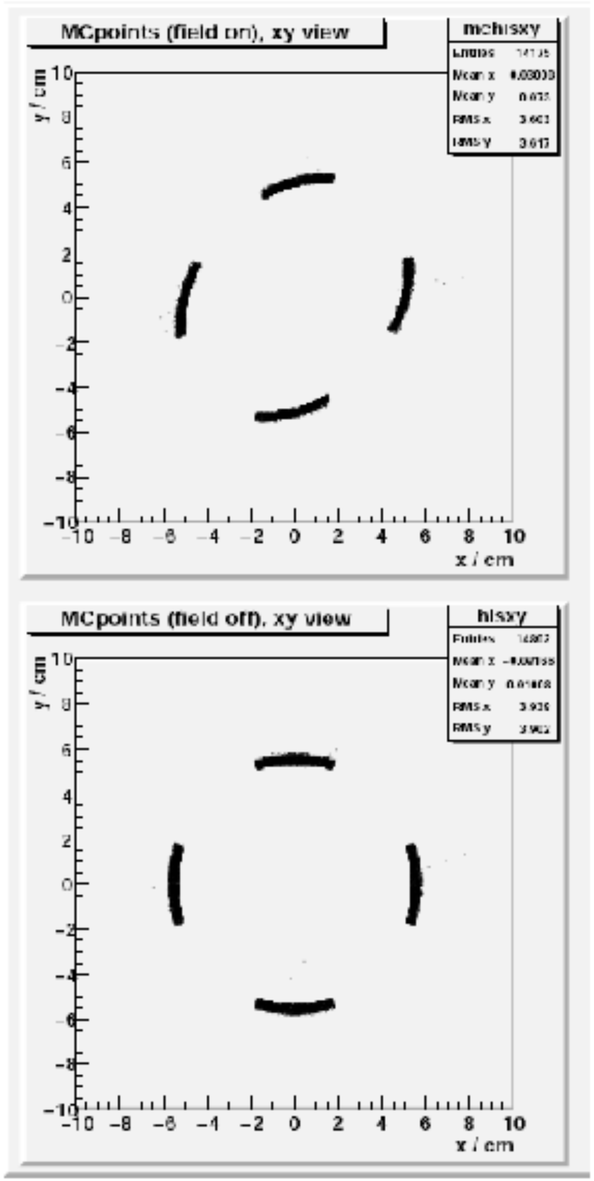


Considerations for field mapping

- 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

	First design			Optimized design		
Component	$0.17T$	$1.0T$	$1.7T$	$0.17T$	$1.0T$	$1.7T$
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 $33\,mm$.