

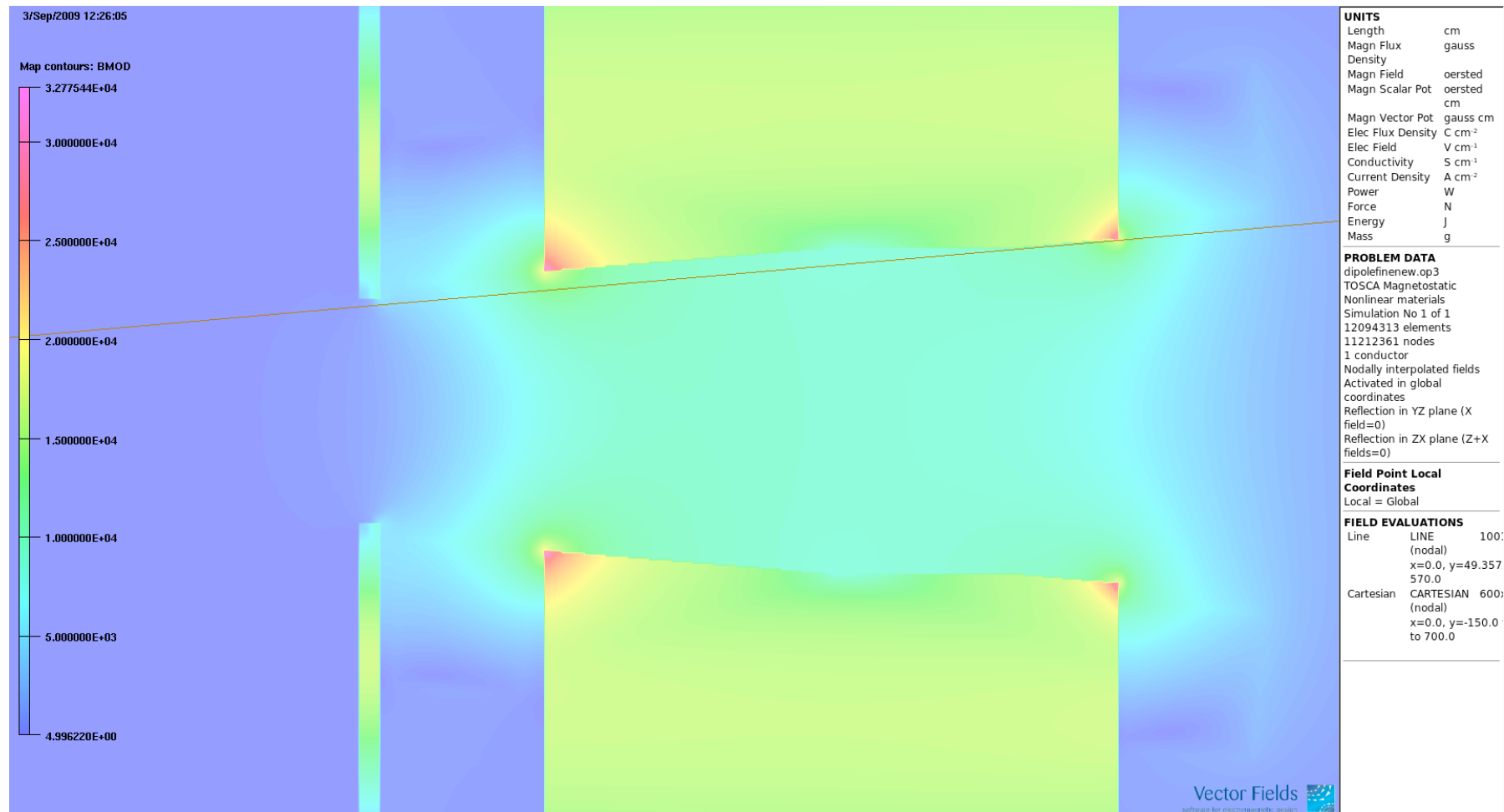
# Magnetic field calculation for Panda dipole magnet

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Glasgow University

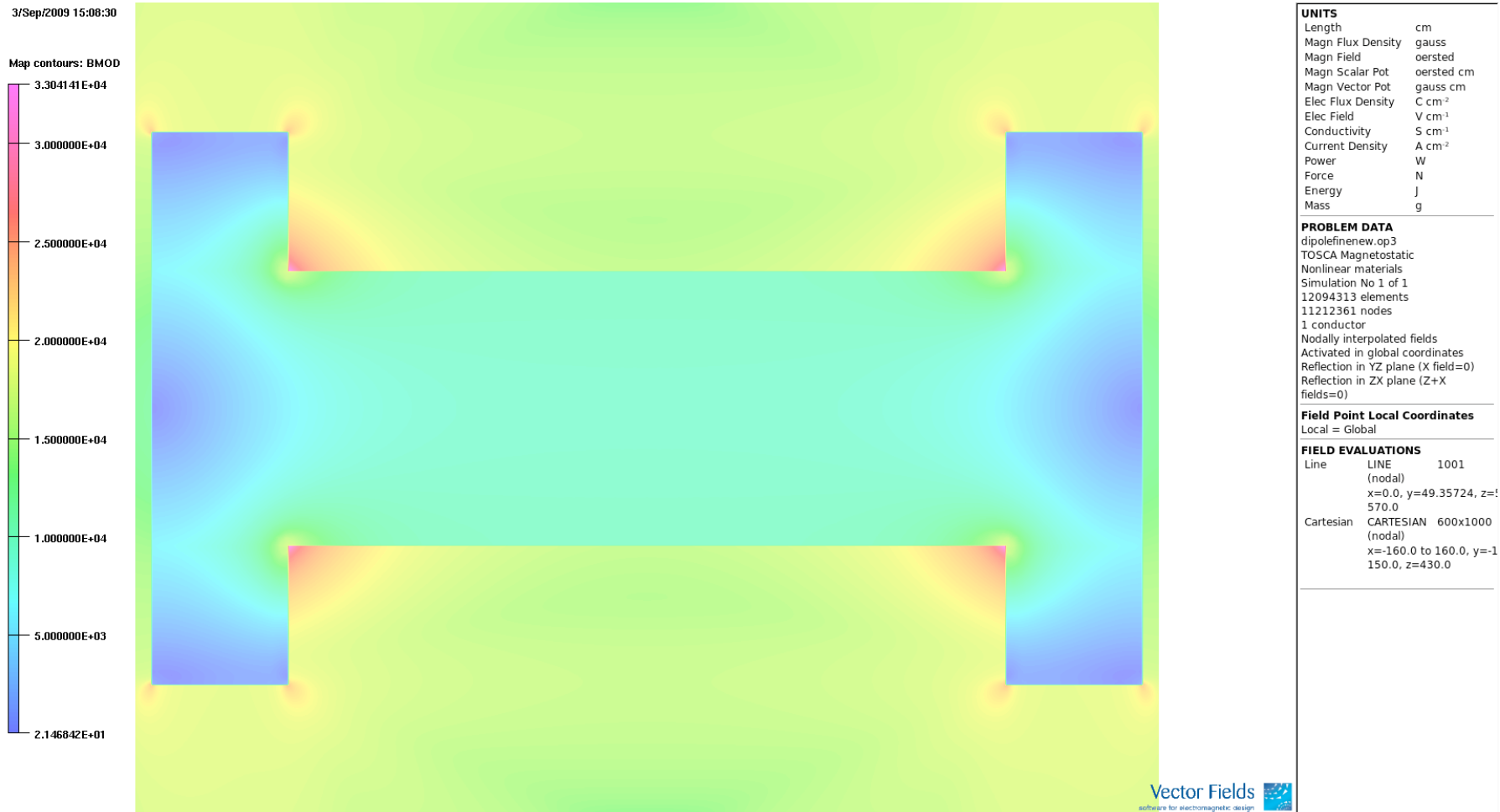
# Contents

- 1 . Dipole field uniformity studies.
- 2. Dipole dynamic properties.
- 3. Conclusions.

# 1. Dipole magnet field distribution in the yz plane (x=0)

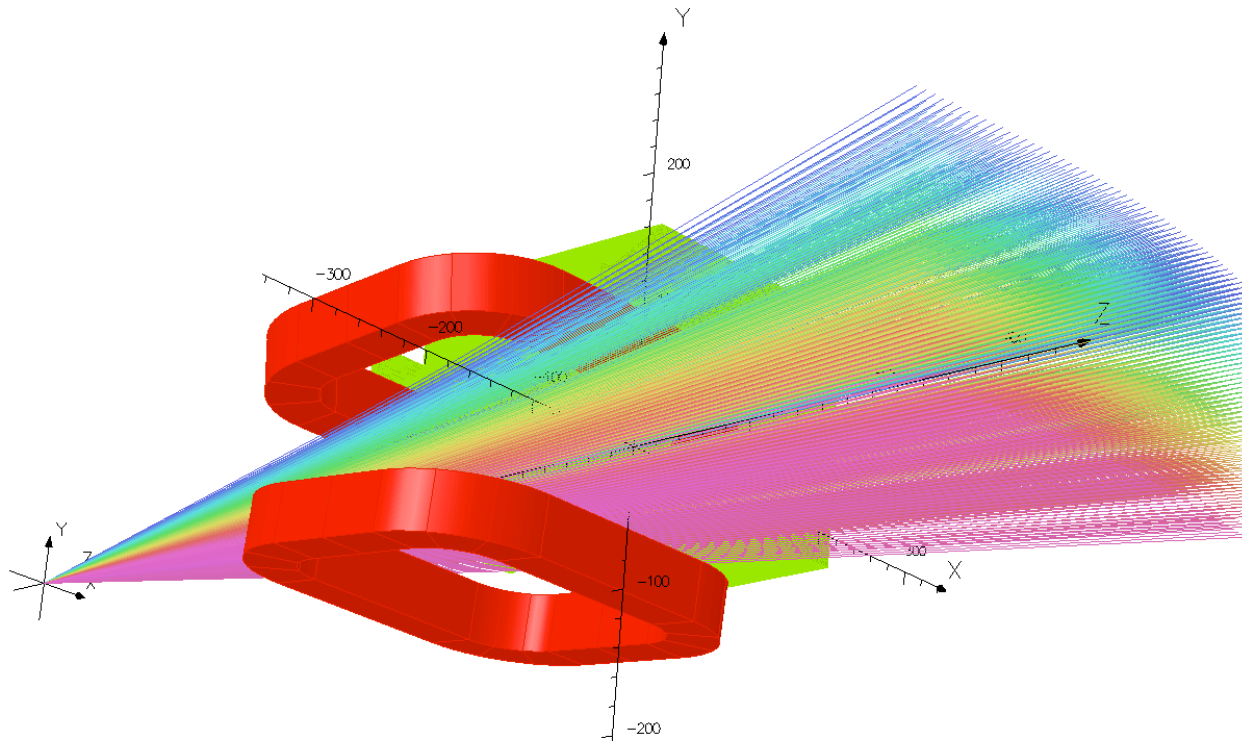


# Dipole magnet field distribution in the xy plane (z=430 cm)



# Antiproton trajectories

4/Sep/2009 13:19:14



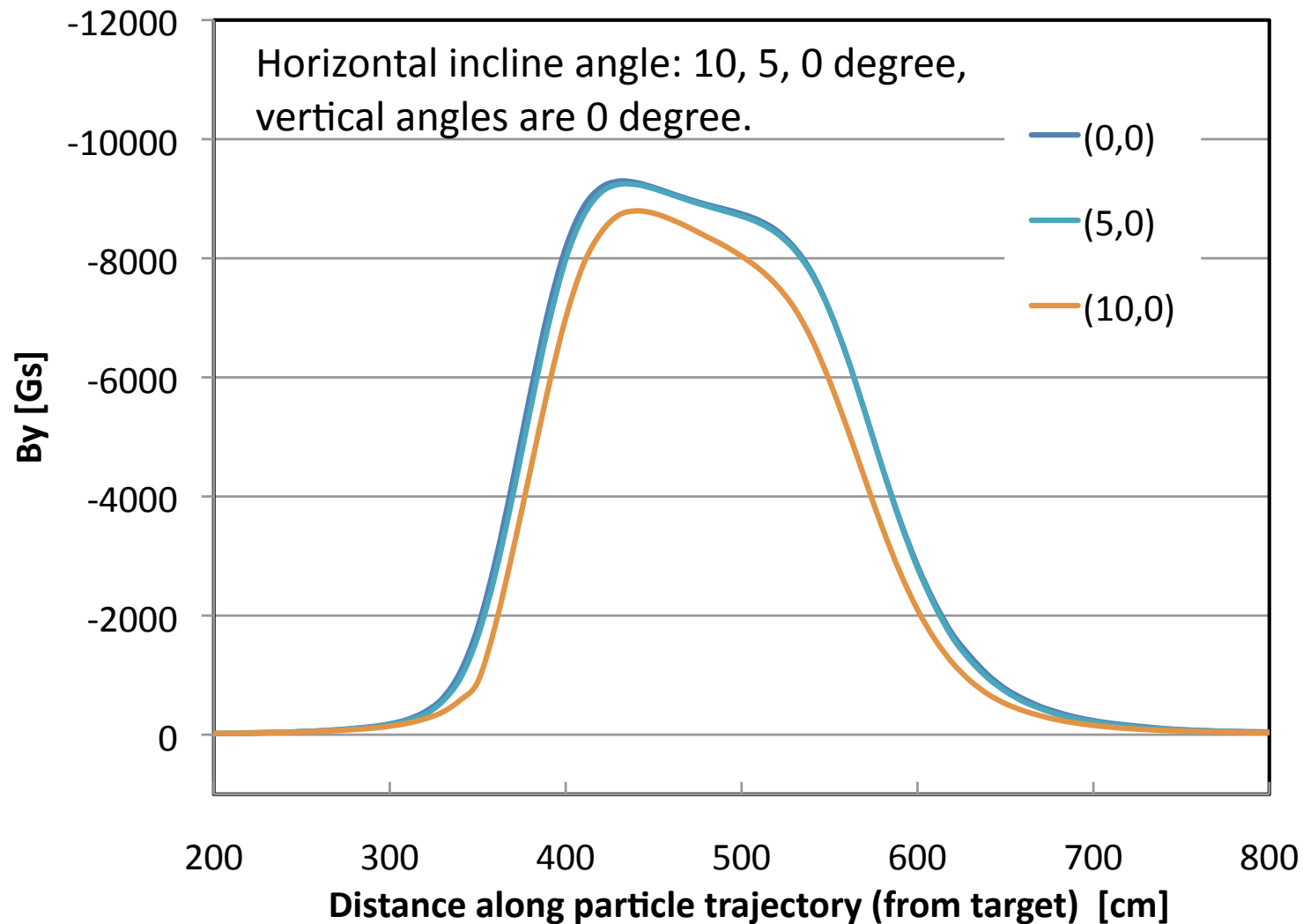
15 GeV /c anti proton beam.  
Starting from target position (0,0,0),  
Horizontal angle: 10 to -10 degree,  
Vertical angle: 5 to -5 degree,  
Angle Steps: 0.4 degree.

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 <sup>-2</sup>
Elec Field	V cm <sup>-1</sup>
Conductivity	S cm <sup>-1</sup>
Current Density	A cm <sup>-2</sup>
Power	W
Force	N
Energy	J
Mass	g

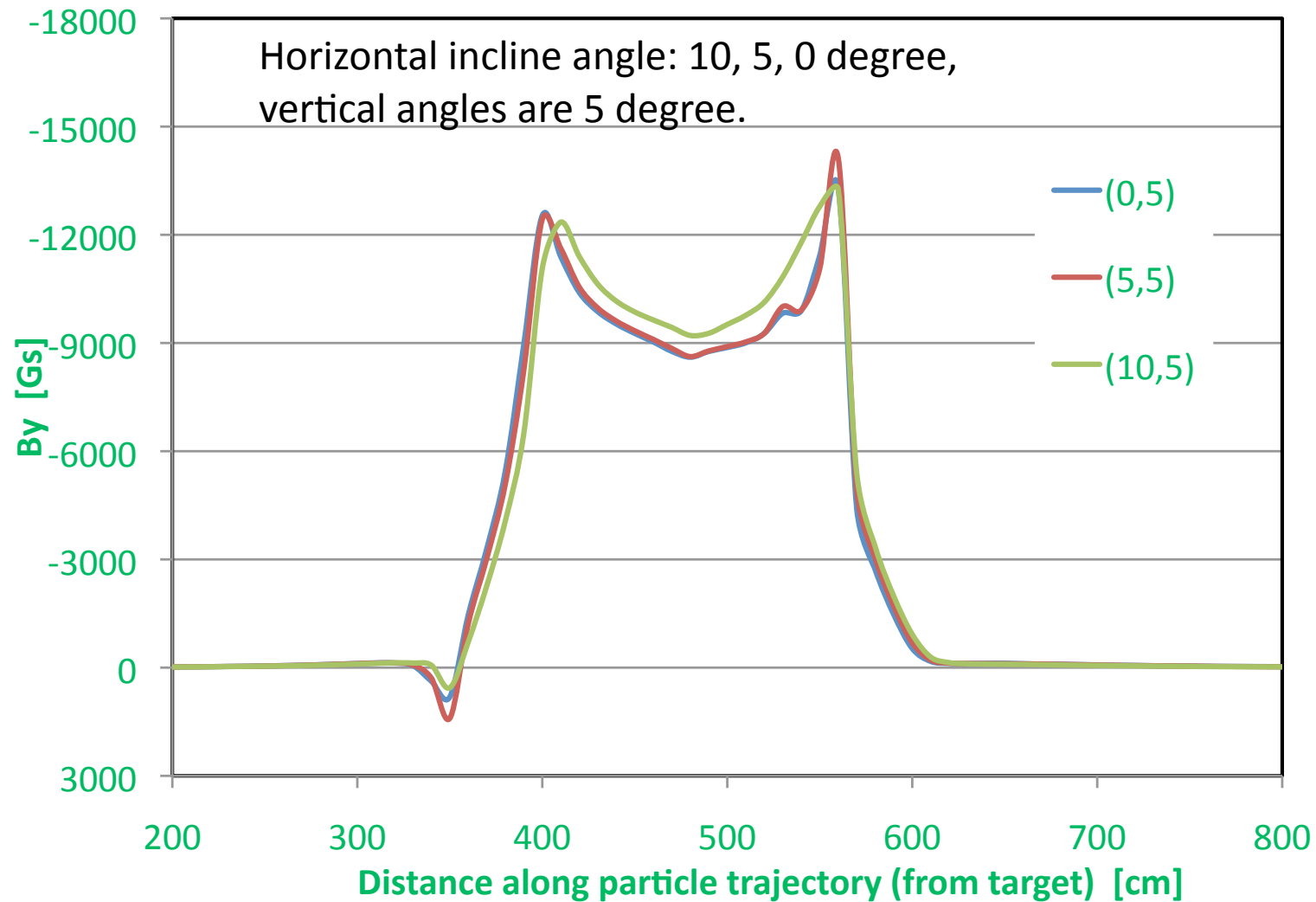
**PROBLEM DATA**  
dipolefinew.op3  
TOSCA Magnetostatic  
Nonlinear materials  
Simulation No 1 of 1  
12094313 elements  
11212361 nodes  
1 conductor  
Nodally interpolated fields  
Activated in global coordinates  
Reflection in YZ plane (X field=0)  
Reflection in ZX plane (Z+X fields=0)

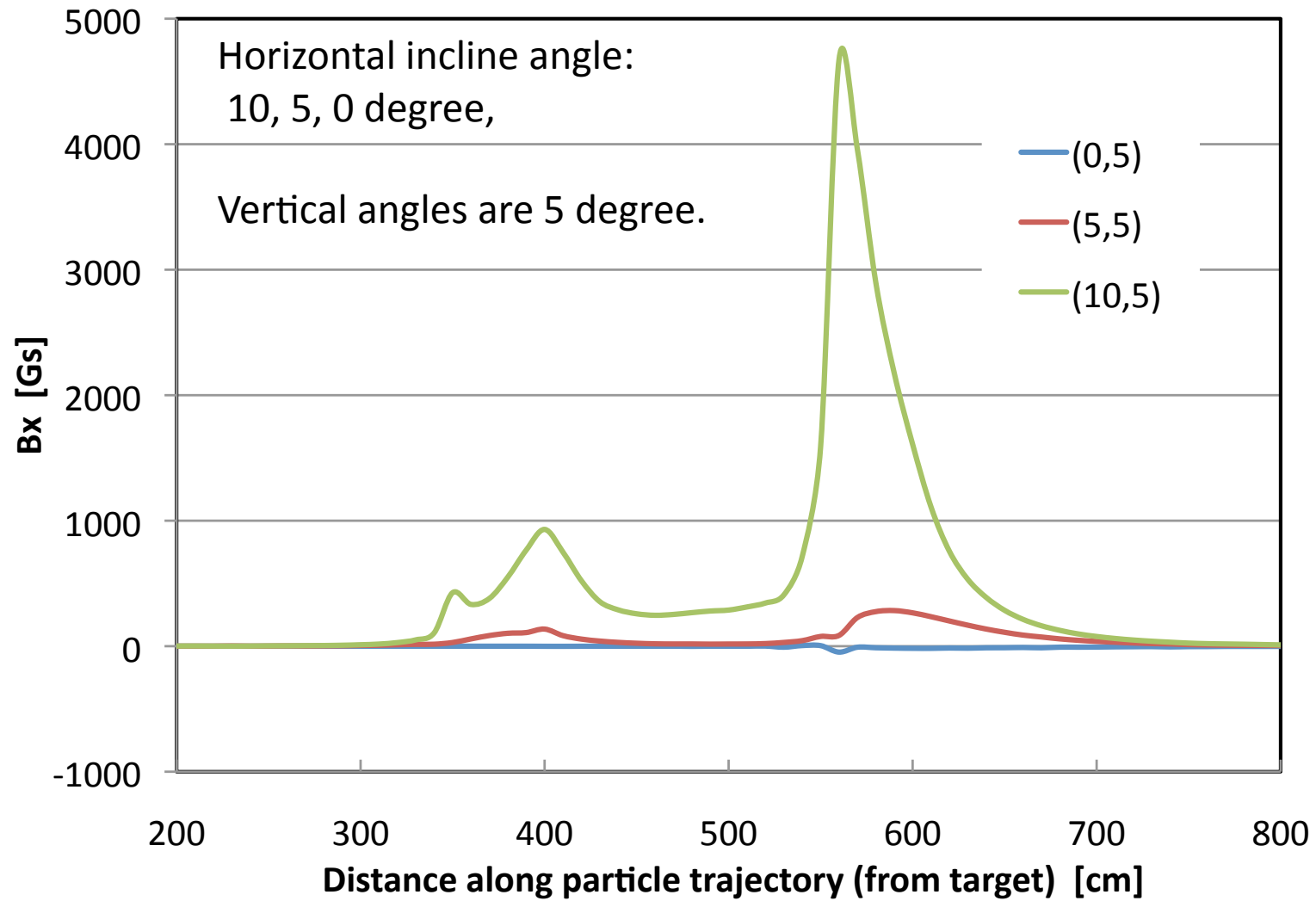
**Field Point Local Coordinates**  
Local = Global

# Dipole fields in the horizontal plane along 15GeV/c antiproton trajectories (from target)



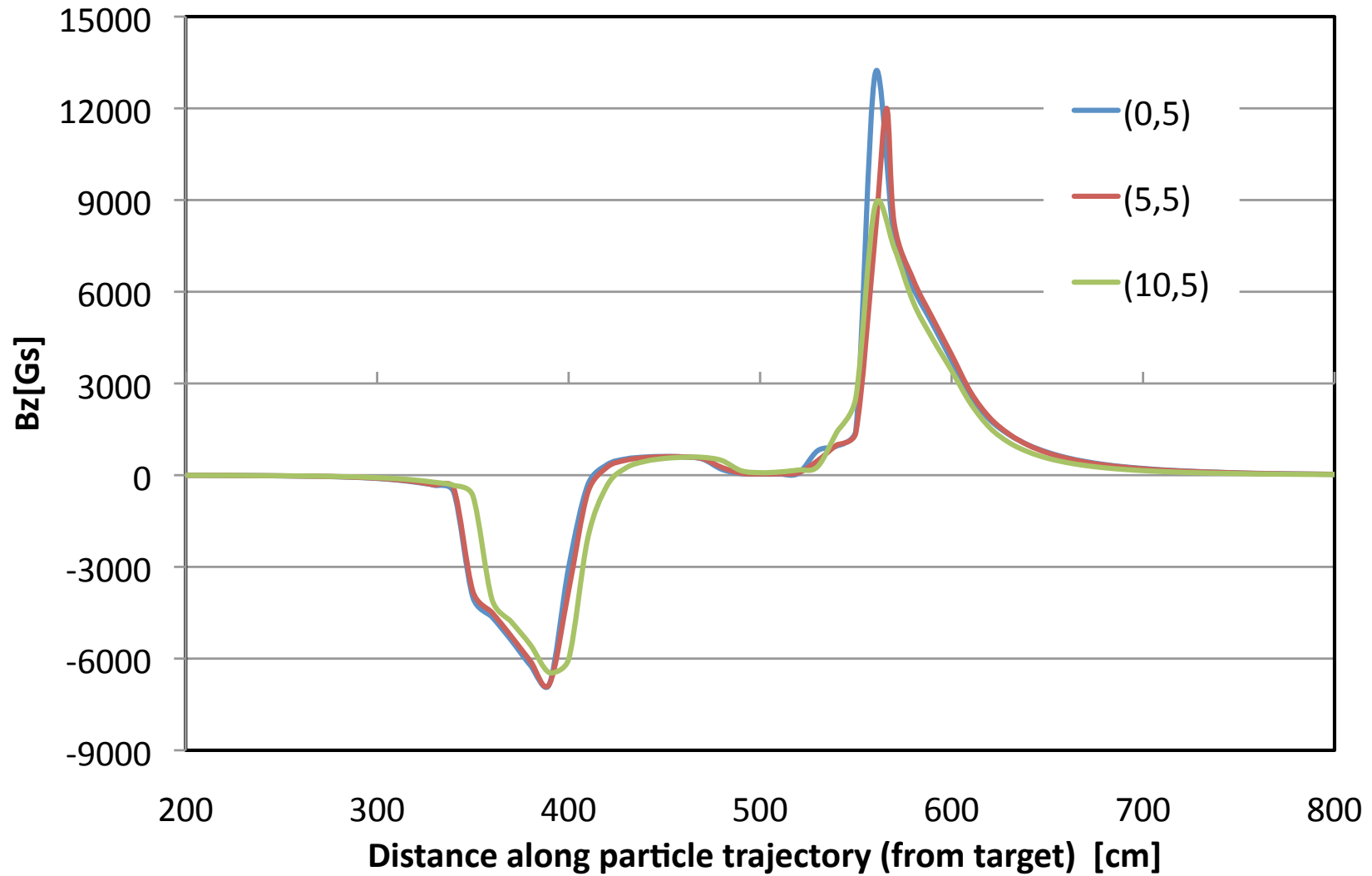
# Dipole fields along 15GeV/c antiproton trajectories





Very strong Bx, leading to vertical bending.

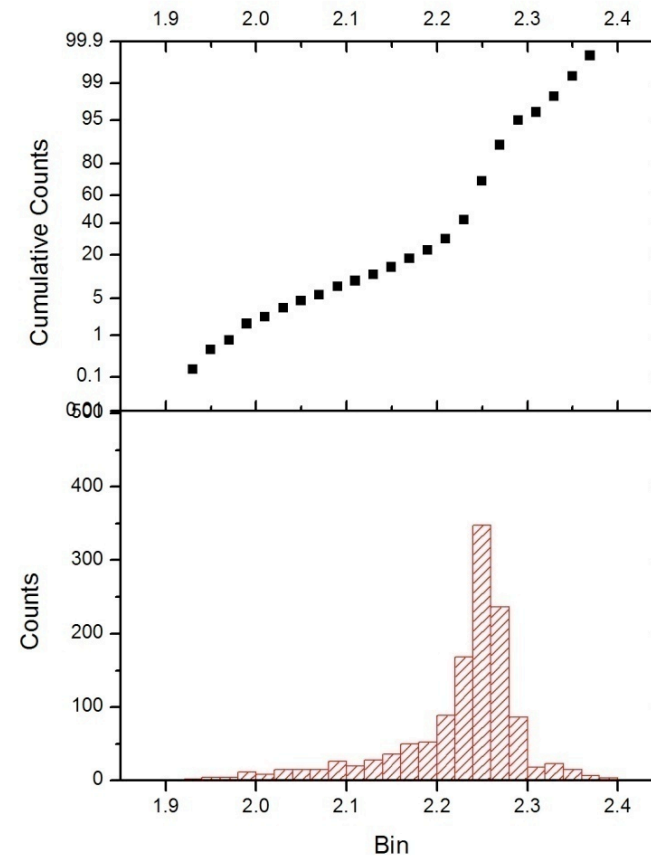
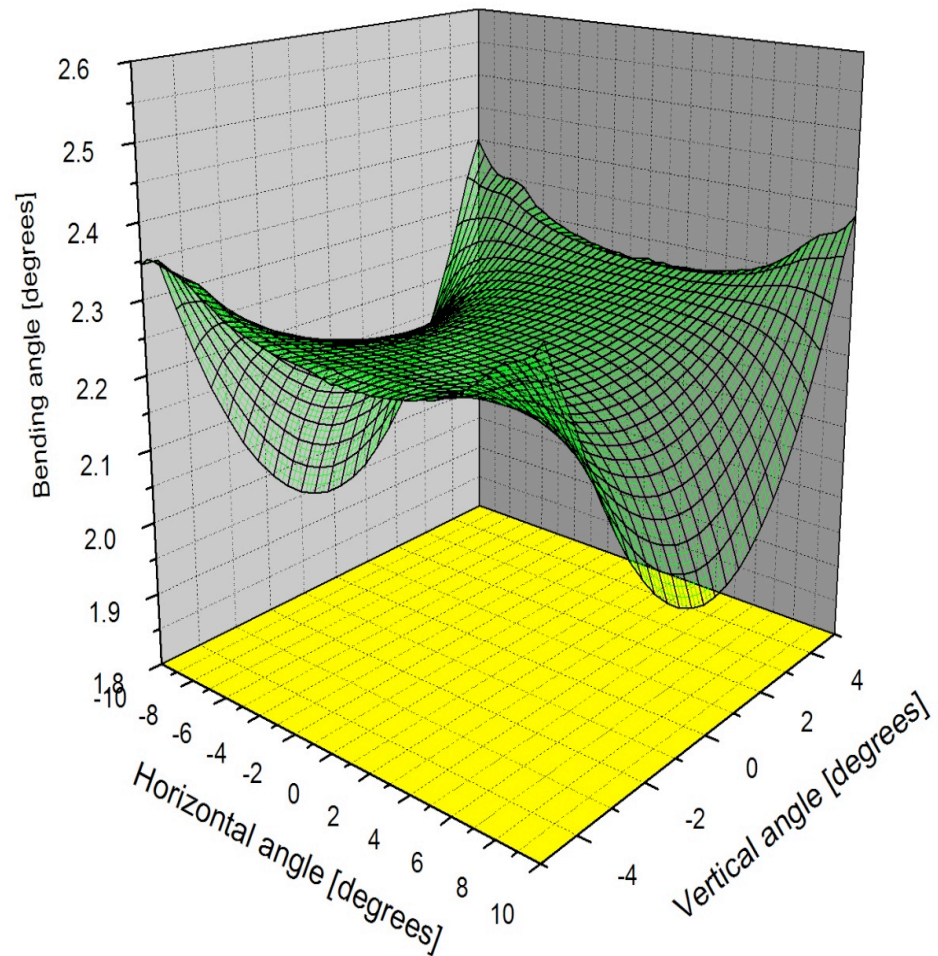




Very strong  $B_z$  component, but the integration is very small.

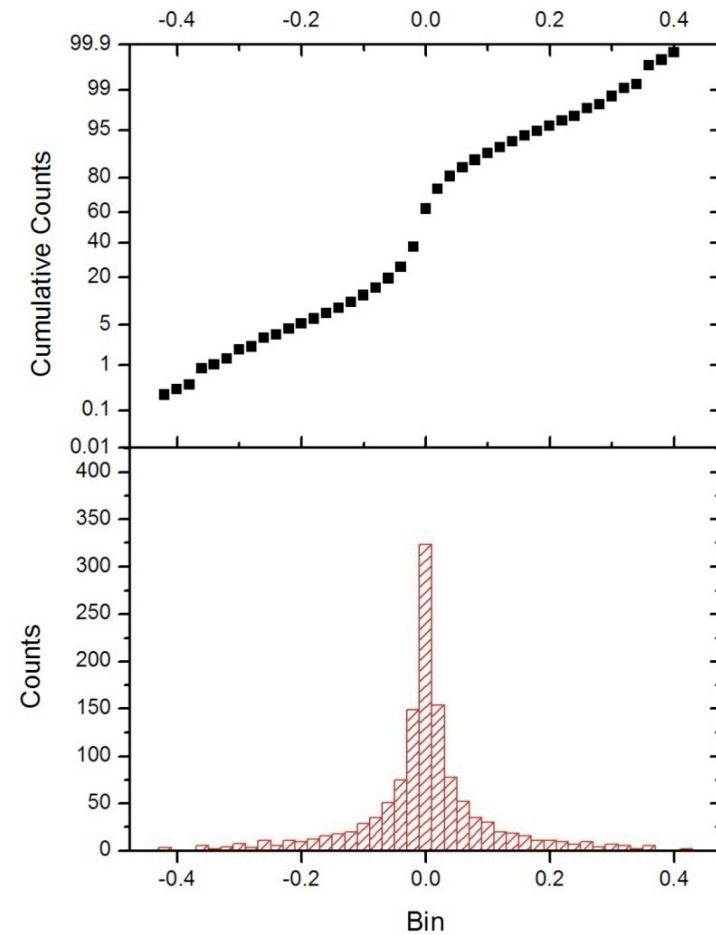
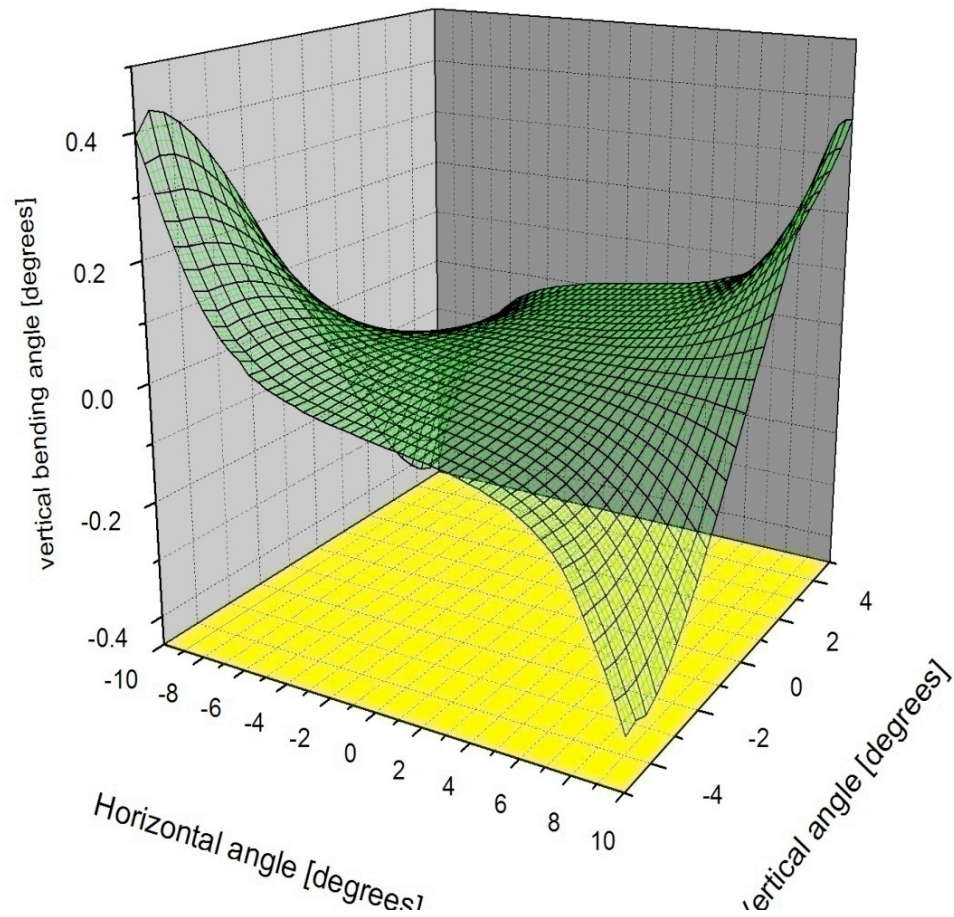
# Horizontal bending angles

(Calculated from the antiproton trajectories )

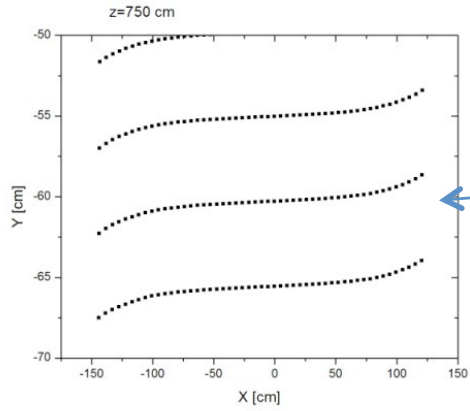
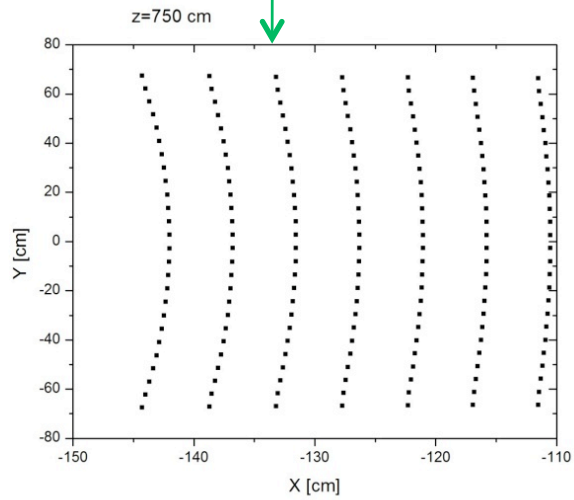


# Vertical bending angles

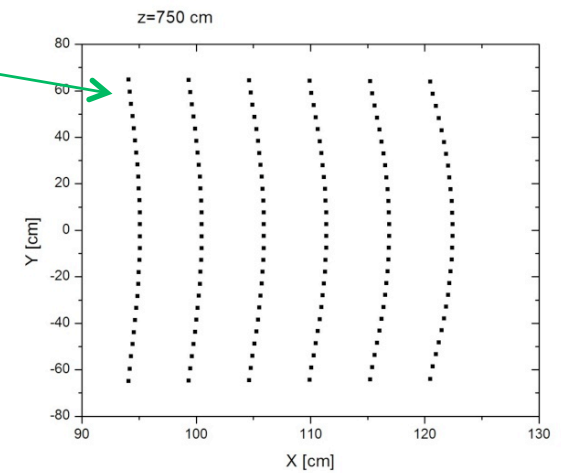
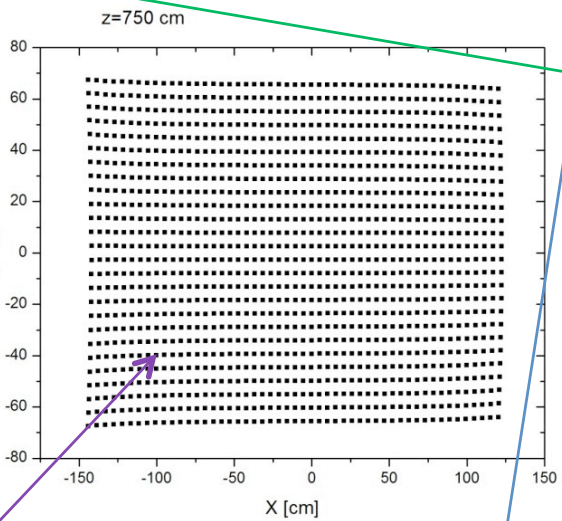
(Calculated from the antiproton trajectories )



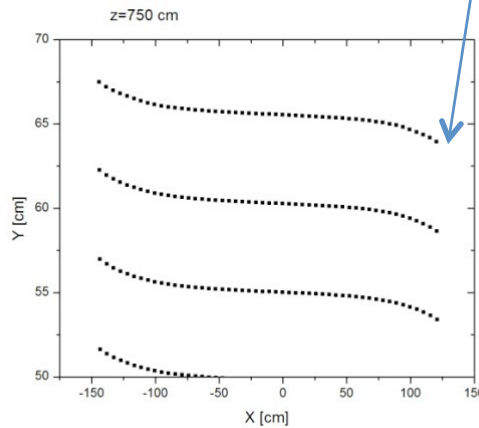
Details about horizontal bending



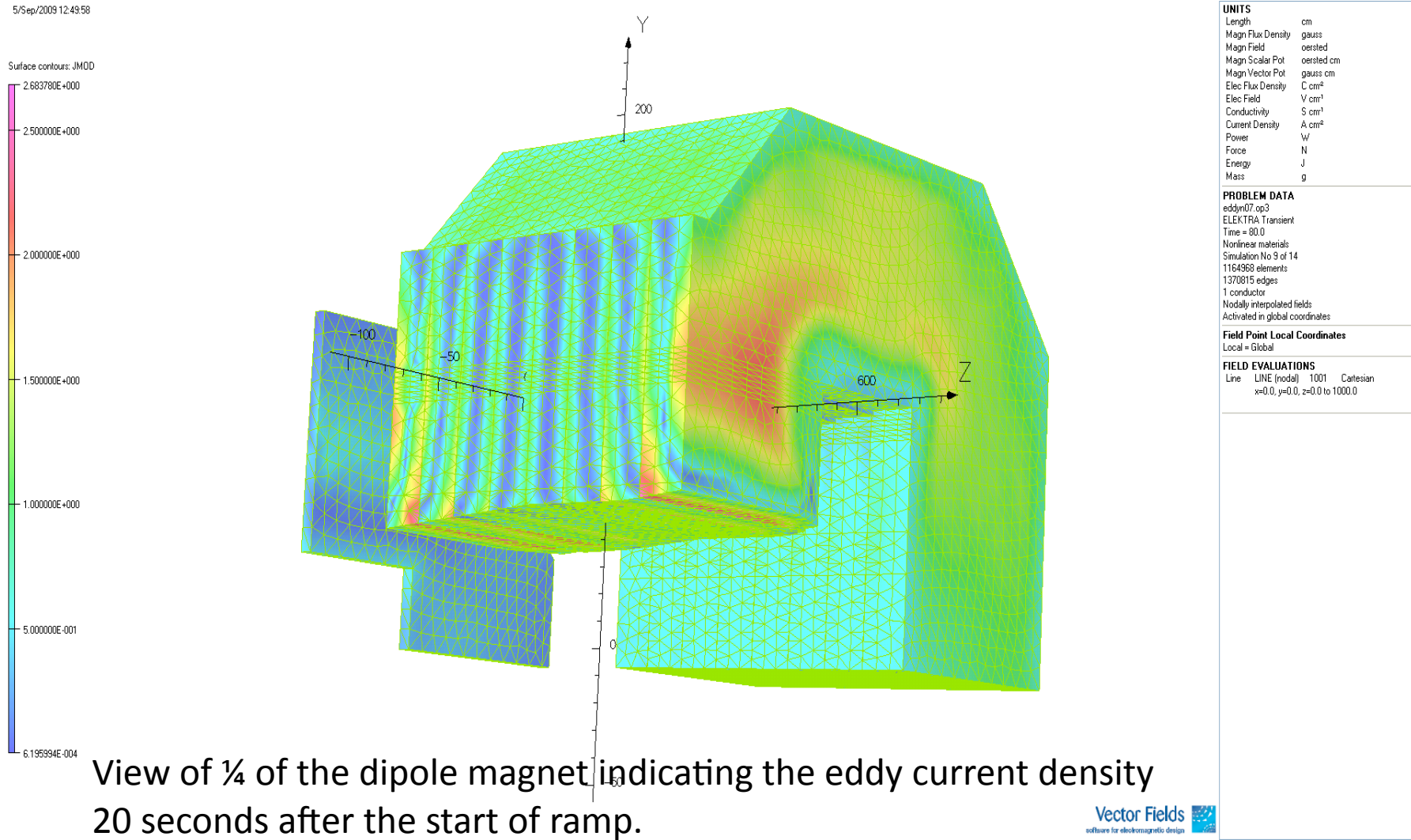
Details about vertical bending



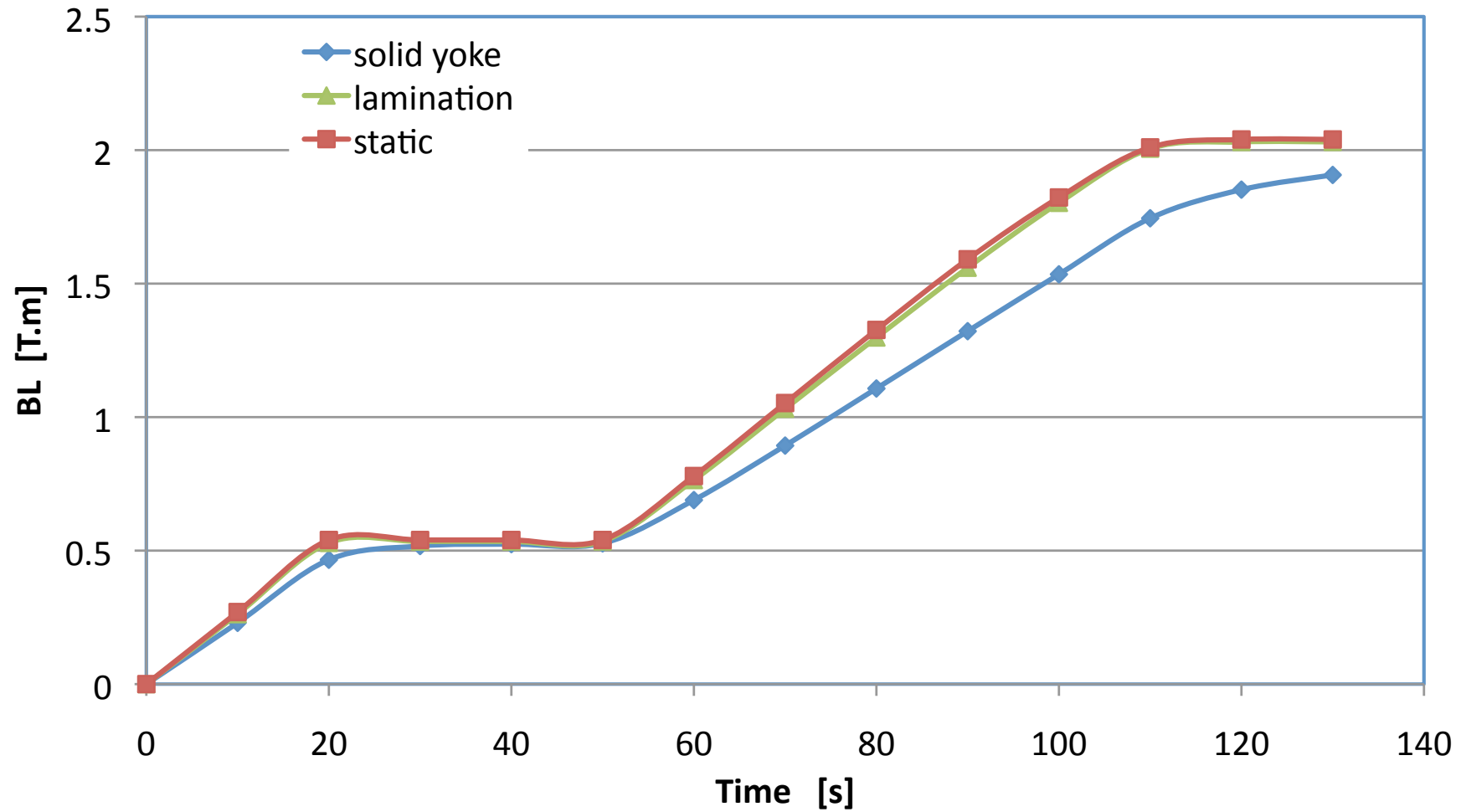
Intersection points of the Antiproton beam with a Vertical plane at  $z=750$  cm



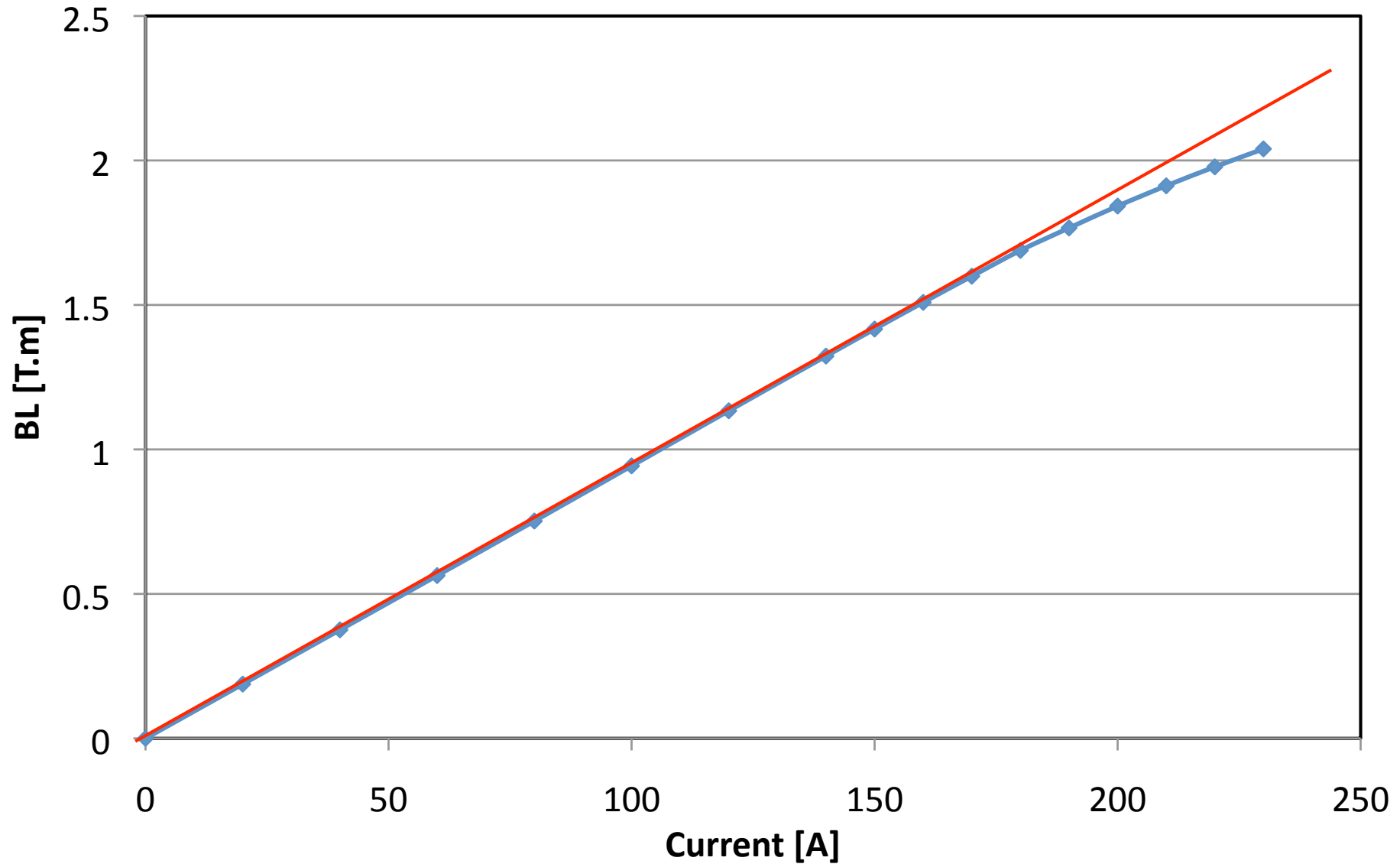
# 2. Dynamical properties.



# Bending power versus ramping time



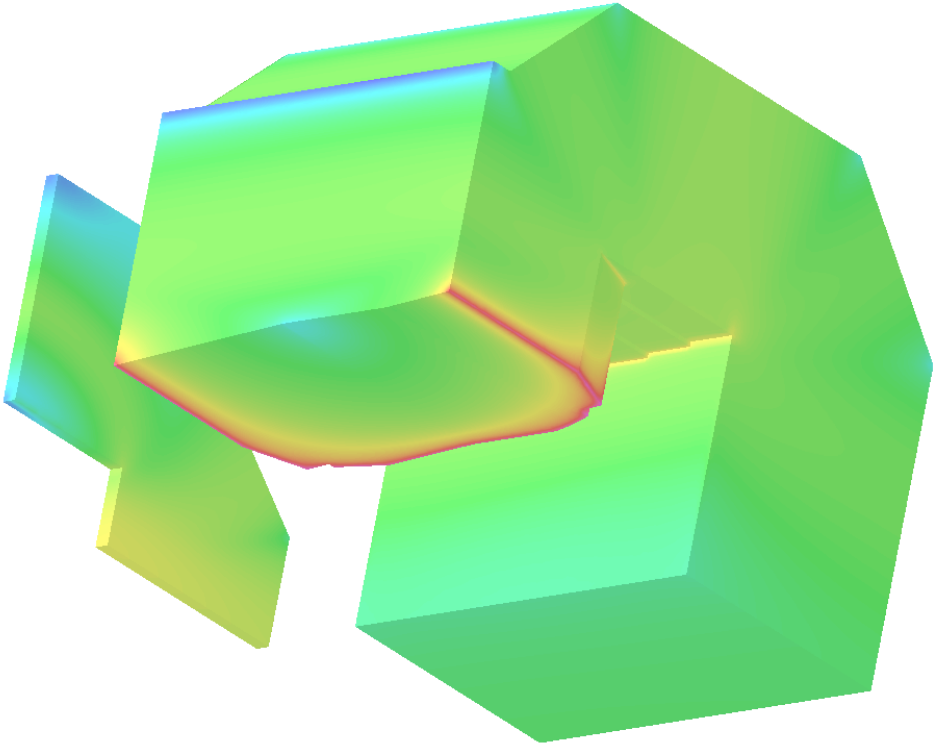
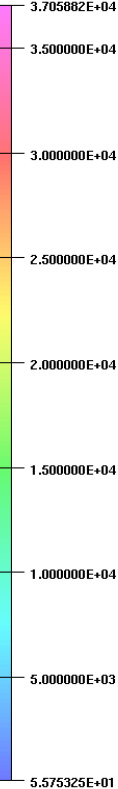
# Dipole magnet transfer function



# Magnetic flux density at surface of the dipole magnet model

3/Sep/2009 13:49:59

Surface contours: BMOD



**UNITS**

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

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Nonlinear materials  
Simulation No 1 of 1  
12094313 elements  
11212361 nodes  
1 conductor  
Nodally interpolated fields  
Activated in global coordinates  
Reflection in YZ plane (X field=0)  
Reflection in ZX plane (Z+X fields=0)

**Field Point Local Coordinates**  
Local = Global

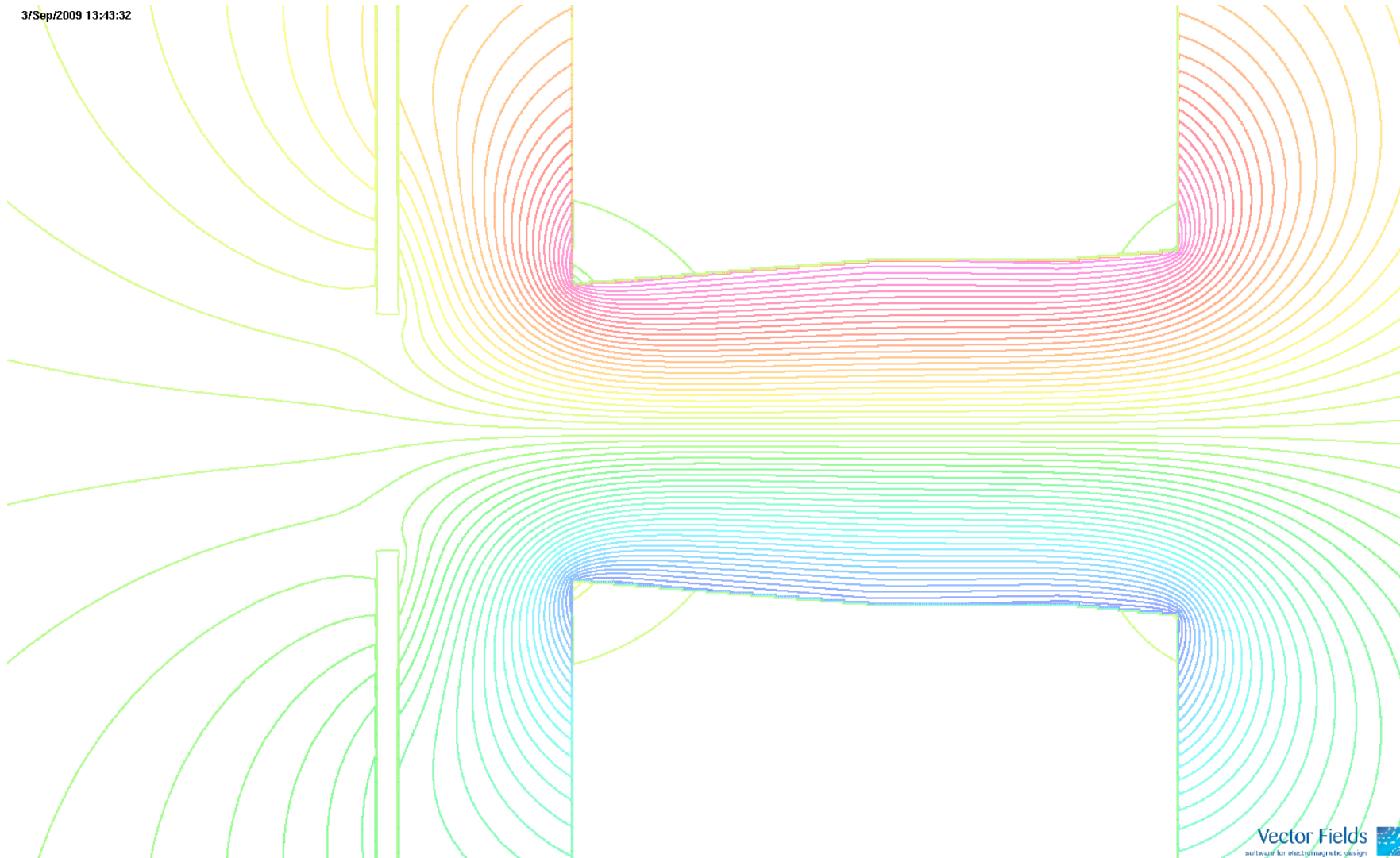
**FIELD EVALUATIONS**

Line	LINE	100:
	(nodal)	
	x=0.0, y=49.357	
	570.0	
Cartesian	CARTESIAN	600:
	(nodal)	
	x=0.0, y=-150.0	
	to 700.0	



# Magnetic scalar potential

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

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dipolefinew.op3  
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Nonlinear materials  
Simulation No 1 of 1  
12094313 elements  
11212361 nodes  
1 conductor  
Nodally interpolated fields  
Activated in global  
coordinates  
Reflection in YZ plane (X  
field=0)  
Reflection in ZX plane (Z+X  
fields=0)

**Field Point Local  
Coordinates**  
Local = Global

**FIELD EVALUATIONS**

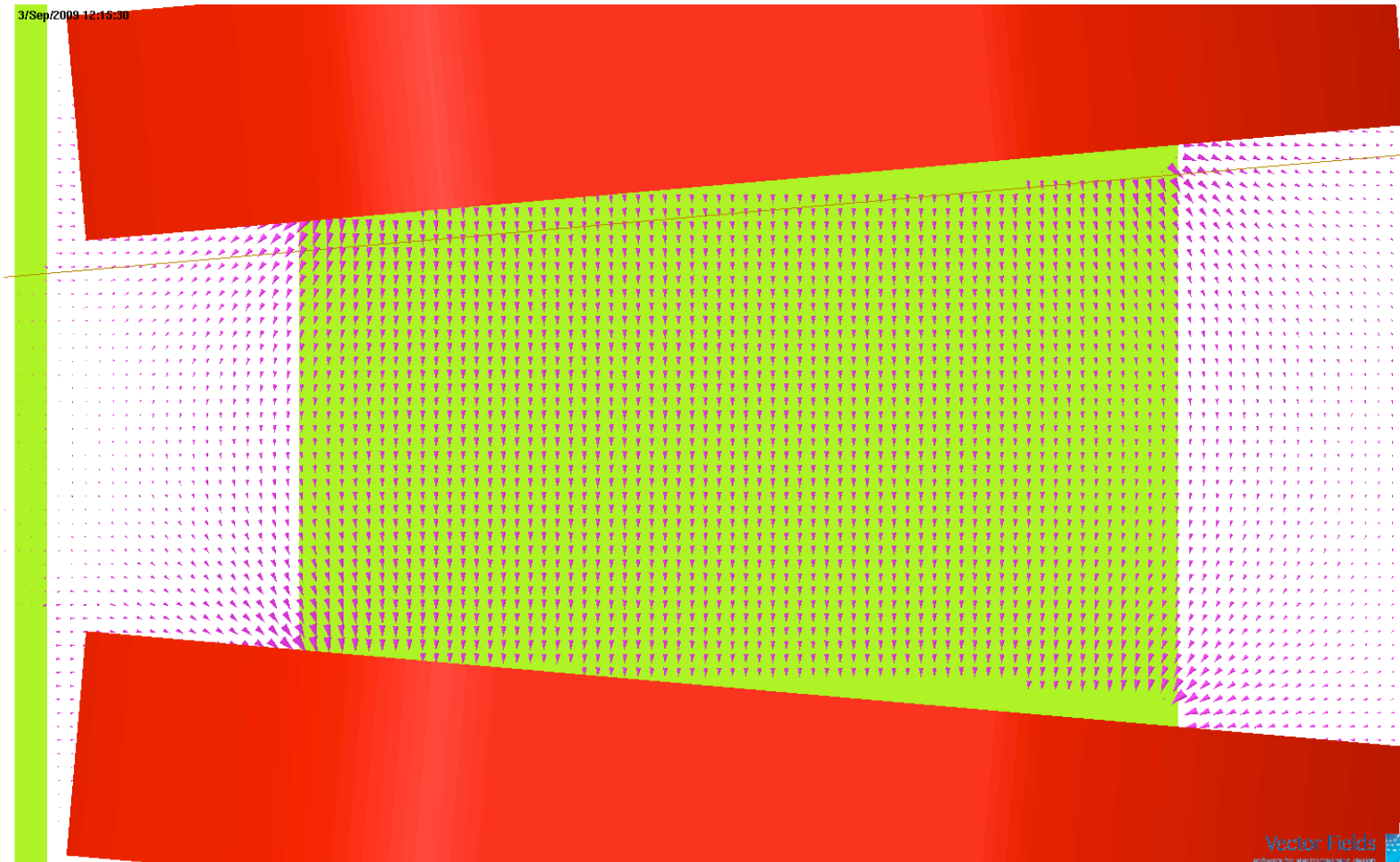
Line	LINE	100:
	(nodal)	
	x=0.0, y=49.357	
	570.0	
Cartesian	CARTESIAN	600:
	(nodal)	
	x=0.0, y=-150.0	
	to 700.0	

# Conclusions

- The dipole magnet fields uniformity was studied. Vertical bending was found.
- The dipole magnet must have laminated yoke, a 20 cm lamination will be good enough.
- The dipole pole shoes are heavily saturated at the edges. Future study is needed for their effects on field repeatability...

# Backup slides

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UNITS	
Length	cm
Magn Flux	gauss
Density	
Magn Field	oersted
Magn Scalar Pot	oersted cm
Magn Vector Pot	gauss cm
Elec Flux Density	C cm <sup>-2</sup>
Elec Field	V cm <sup>-1</sup>
Conductivity	S cm <sup>-1</sup>
Current Density	A cm <sup>-2</sup>
Power	W
Force	N
Energy	J
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TOSCA Magnetostatic  
Nonlinear materials  
Simulation No 1 of 1  
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11212361 nodes  
1 conductor  
Nodally interpolated fields  
Activated in global  
coordinates  
Reflection in YZ plane (X  
field=0)  
Reflection in ZX plane (Z+X  
fields=0)

**Field Point Local  
Coordinates**  
Local = Global

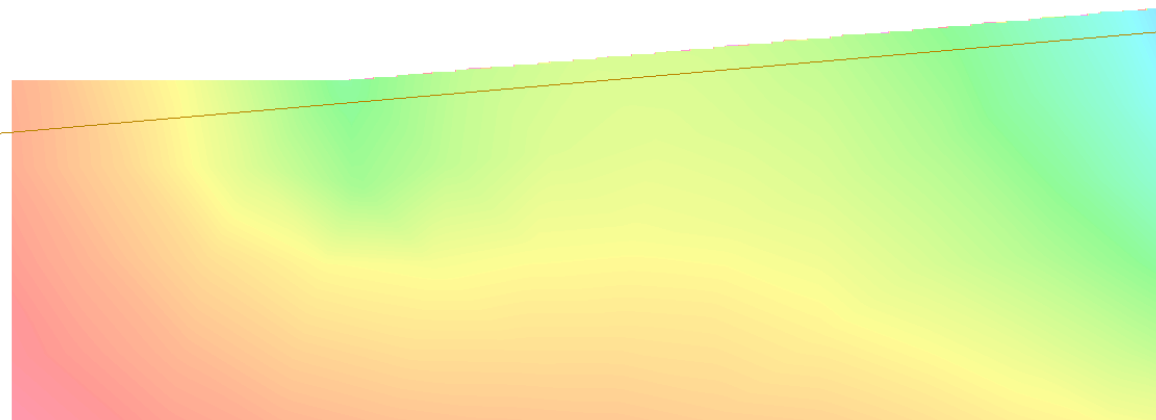
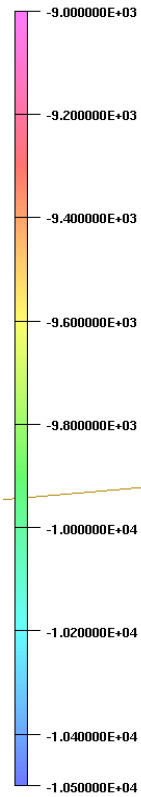
**FIELD EVALUATIONS**

Line	LINE	100:
	(nodal)	
	x=0.0, y=49.357	
	570.0	
Cartesian	CARTESIAN	120:
	(nodal)	
	x=0.0, y=-150.0	
	z=200.0 to 700.0	

# Dipole field map (Hy)

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Map contours: Hy



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 <sup>-2</sup>
Elec Field	V cm <sup>-1</sup>
Conductivity	S cm <sup>-1</sup>
Current Density	A cm <sup>-2</sup>
Power	W
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 11212361 nodes  
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 Nodally interpolated fields  
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 Reflection in YZ plane (X field=0)  
 Reflection in ZX plane (Z+X fields=0)

**Field Point Local Coordinates**  
 Local = Global

FIELD EVALUATIONS			
Line	LINE (nodal)	1001	Cartesian
		x=0.0, y=49.35724, z=550.0 to 570.0	
Cartesian	CARTESIAN (nodal)	600x100	Cartesian
		x=0.0, y=40.0 to 60.0, z=520.0 to 542.0	