Field Mapping of Vertical Coils and BigBite Fringe Field

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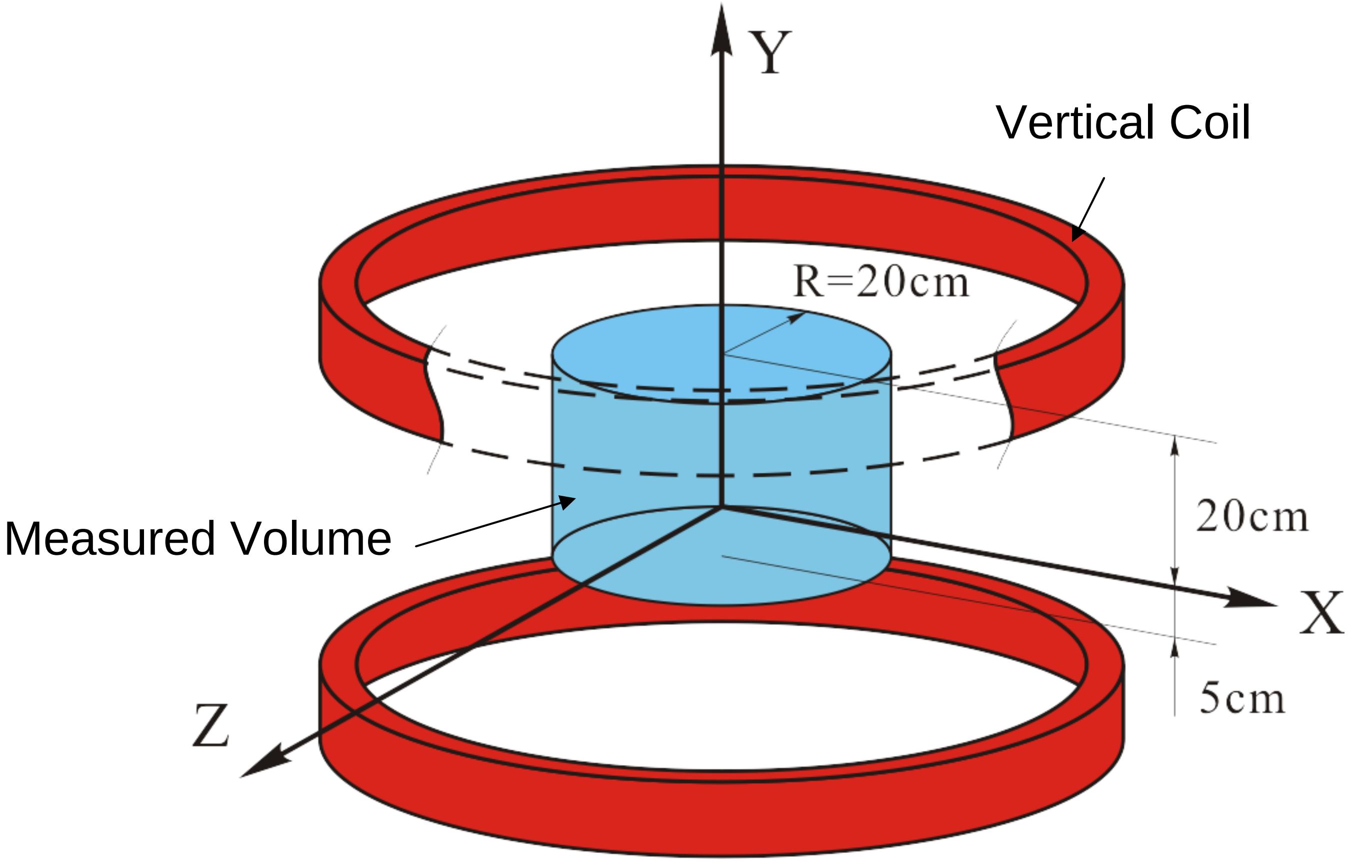
Parameters of Three Coils

Coils	Radius (cm)	Field Direction	Field (G)
Small	66.75	Z	28
Large	75.80	X	28
Vertical	94.62	Y	28

Measured Volume

- A volume of a cake box with R = 20 cm and H = 25 cm



Symmetries in Gradients

- Static magnetic field in vacuum satisfies the following Maxwell equation:

$$\nabla \cdot \vec{B} = 0 \qquad \nabla \times \vec{B} = 0$$

- So the components of gradients have the following relations and only 5 independent elements left:

$$dBx / dx + dBy / dy + dBz / dz = 0$$

$$dBx / dy = dBy / dx$$

$$dBy / dz = dBz / dy$$

$$dBz / dx = dBx / dz$$

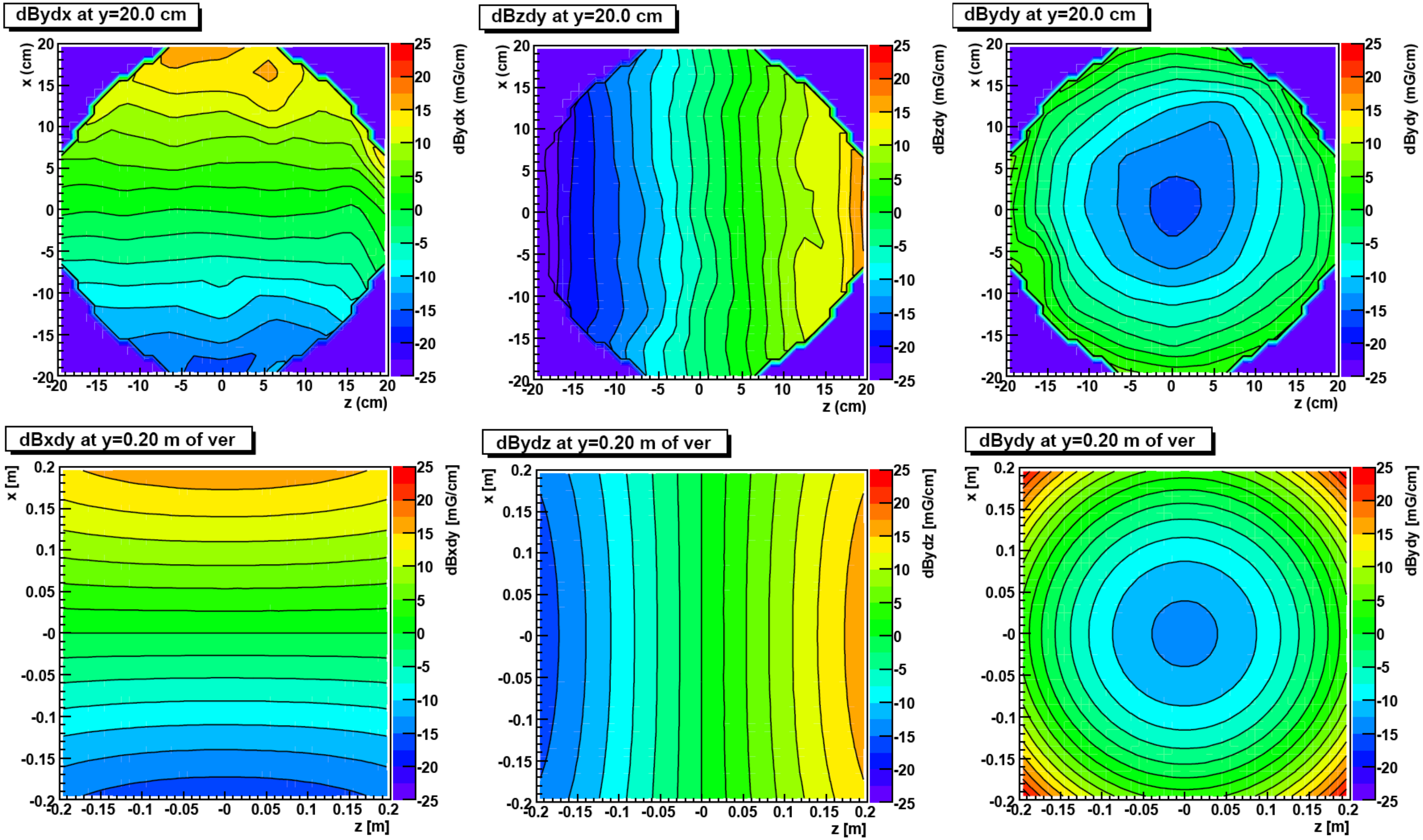
Gradients in Vertical Coil

- With I = 16 A, the average field generated by vertical coils is about 31 Gaus in Y direction.
- Most gradients measured in the volume are well within our requirement (Absolute values < 10 mG/cm):

Component	Gradient (mG/cm)	Component	Gradient (mG/cm)
dBx/dy	-1.1±5.4	dBx/dx	1.8±3.7
dBy/dz	-3.6±7.4	dBy/dy	-3.4±5.0
dBz/dx	0.5±3.4	dBz/dz	1.6±4.6

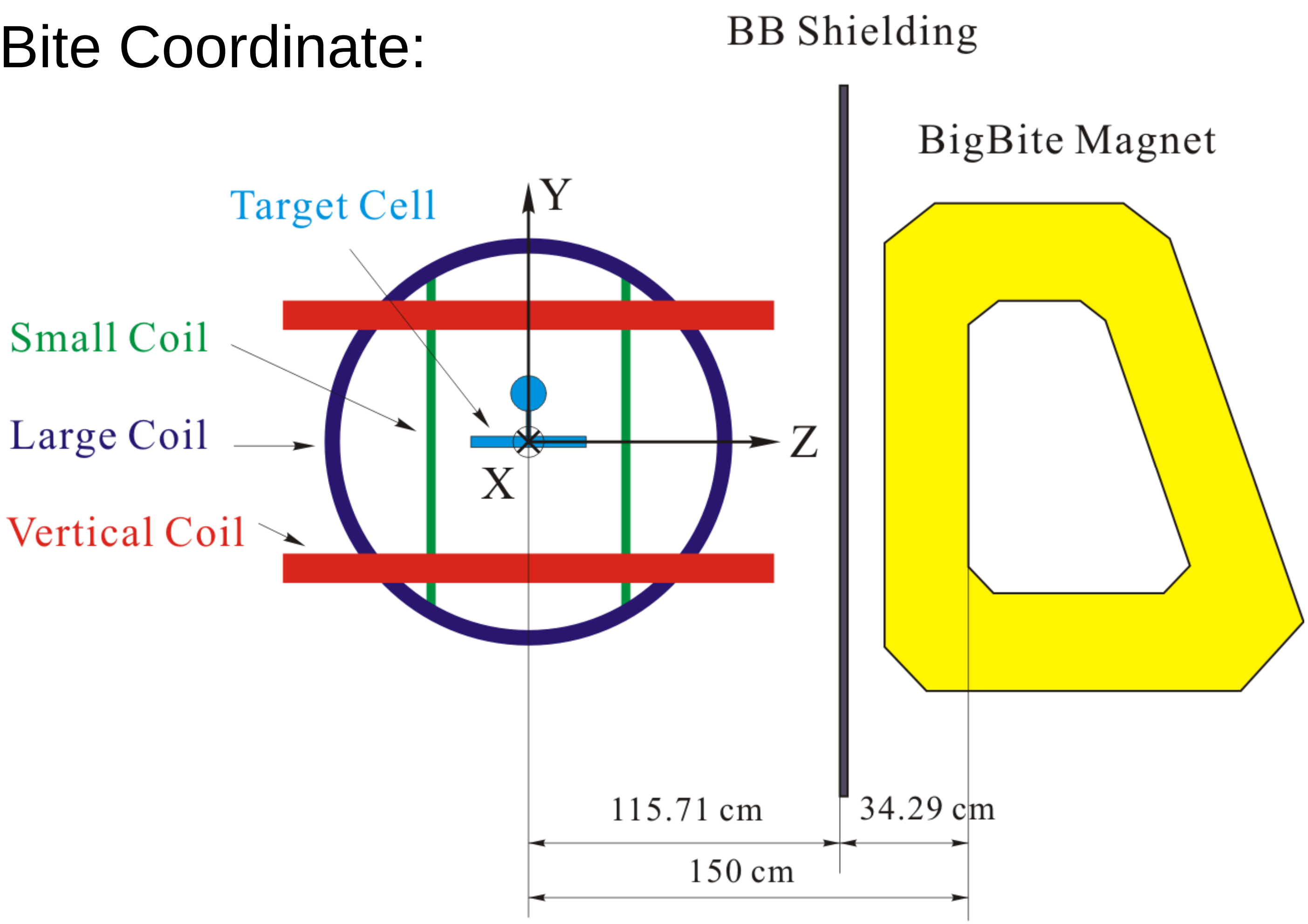
- Large gradients (~20 mG/cm) only happen at the edge of the volume, espcially at Y=20 cm plane.

Comparison to Simulation



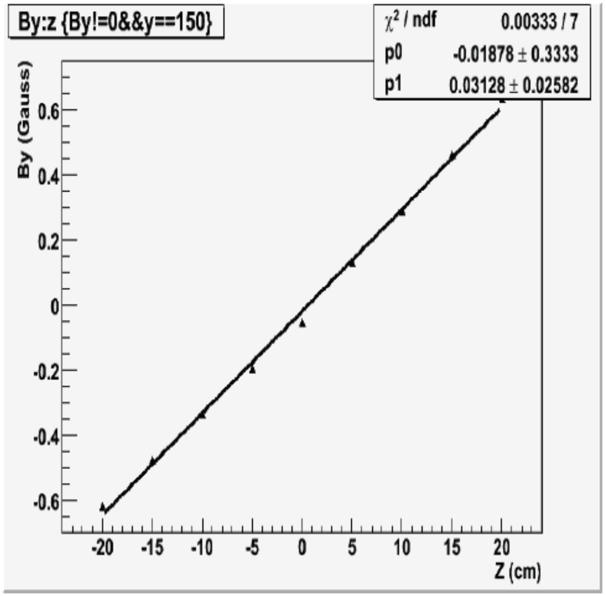
Shielding of BigBite Fringe Field

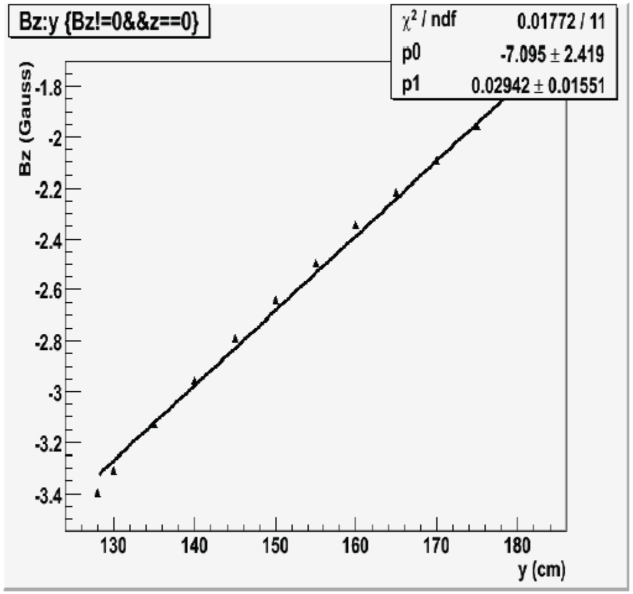
- BigBite Coordinate:



Previous Result without Shielding

- Measured by Xiaofeng, Chiranjib, Xin and Huan.
- Measured with 710 A current





dBz/dx = 31 mG/cm

dBx/dz = 29 mG/cm

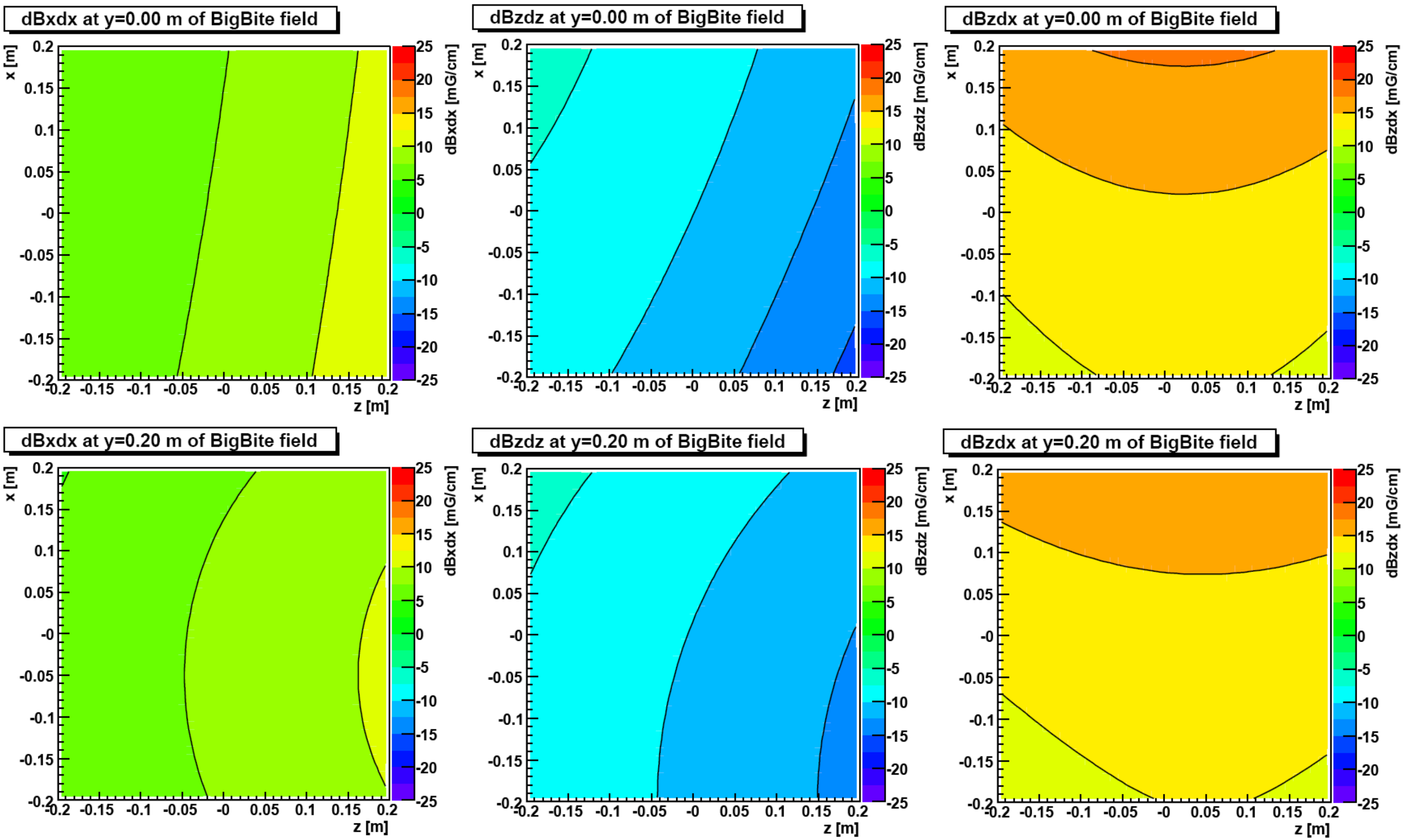
Fringe Field with Shielding

- Measured with 710 A current
- Field Gradients are quite uniform (~±3mG/cm)
- Average values are:

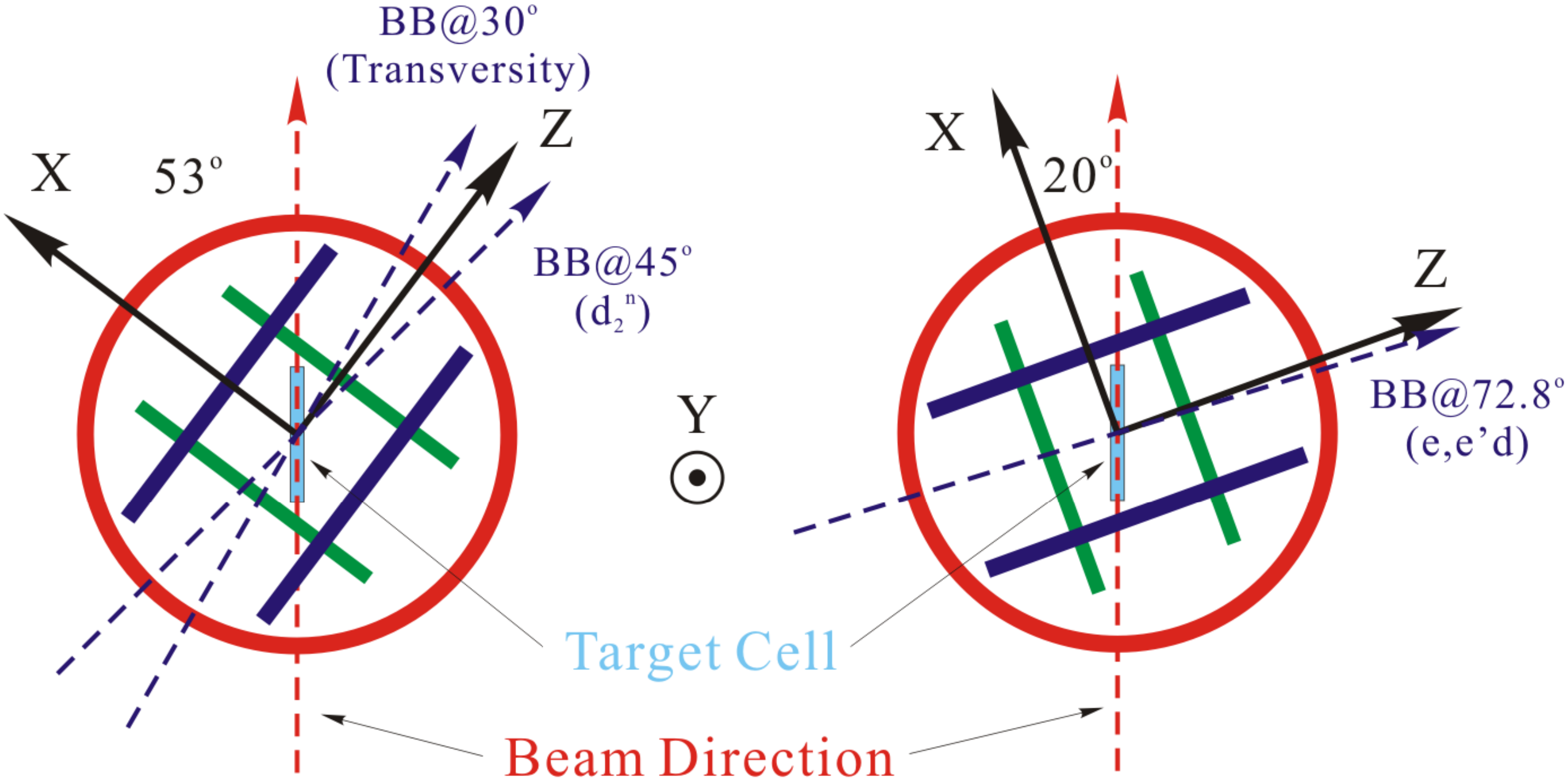
Component	Gradient (mG/cm)	Component	Gradient (mG/cm)
dBx/dy	-1.8	dBx/dx	7.7
dBy/dz	-4.0	dBy/dy	2.2
dBz/dx	14.1	dBz/dz	-9.9

A factor of 2 reduction!

Some Plots of BB Fringe Field



Coil Orientations

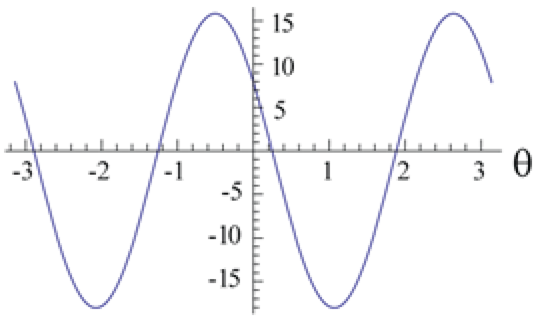


Magnetic field directions:

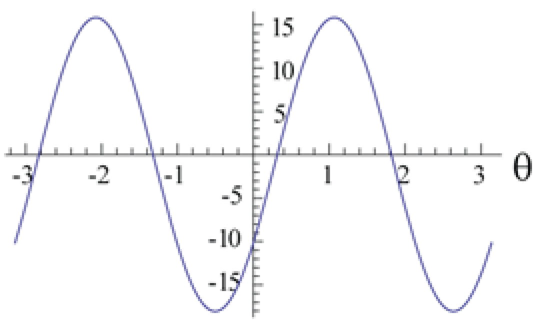
Small Coil: Z
Large Coil: X
Vertical Coil: Y

Fringe Field in Different Experiments

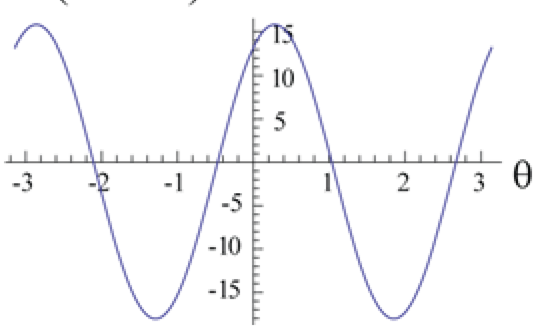
dBx/dx (mG/cm)



dBz/dz (mG/cm)



dBz/dx (mG/cm)

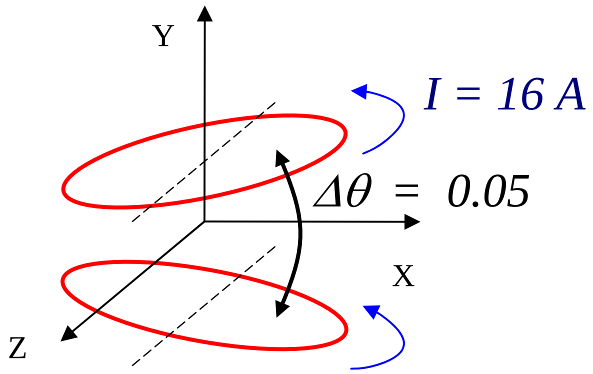


	Transver-sity	g2/d2	(e,e'd)
Angle of BigBite	-7^o	8^o	2.8^o
dBx/dx (mG/cm)	11.1	3.6	6.5
dBz/dz (mG/cm)	-13.3	-5.8	-8.7
dBz/dx (mG/cm)	11.7	16.3	15.1

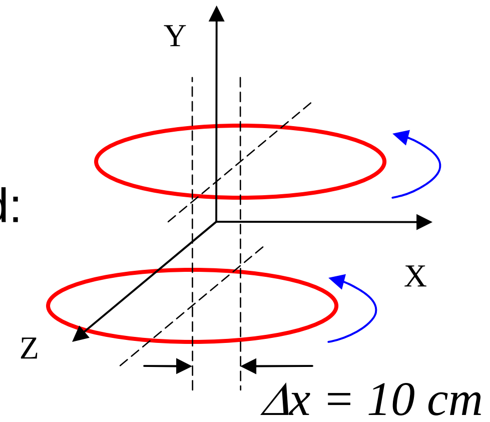
Additional Gradients from Different Coil Setups

- Mis-alignment from ideal position:

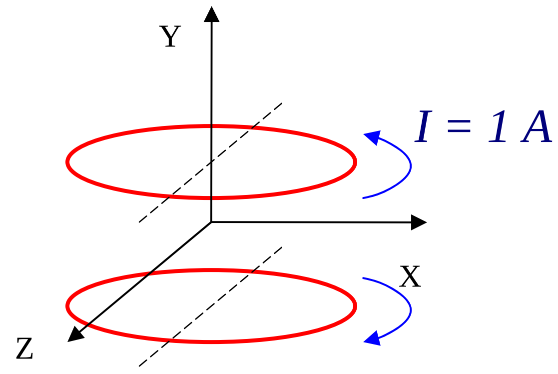
Tilted:



Shifted:



- Anti-Helmholtz Coil:



Effects of Different Setups

- Titled coils (Opening to X direction by $\Delta\theta$ = 0.05):
  - Create a uniform additional gradient of dBy/dx = 15 mG/cm;
  - No other significant gradient components.

- Shifted coils (Shifted in X direction by Δx = 10 cm):
  - Create a non-uniform gradient in dBx/dx and dBy/dy along x direction ($\pm$10 mG/cm);

- Anti-Helmholtz coils (I = 1 A):
  - Create uniform additional gradients in dBy/dy, dBx/dx and dBz/dz with dBx/dx = dBz/dz = - 0.5 dBy/dy = 12 mG/cm;
  - No other significant gradient components.

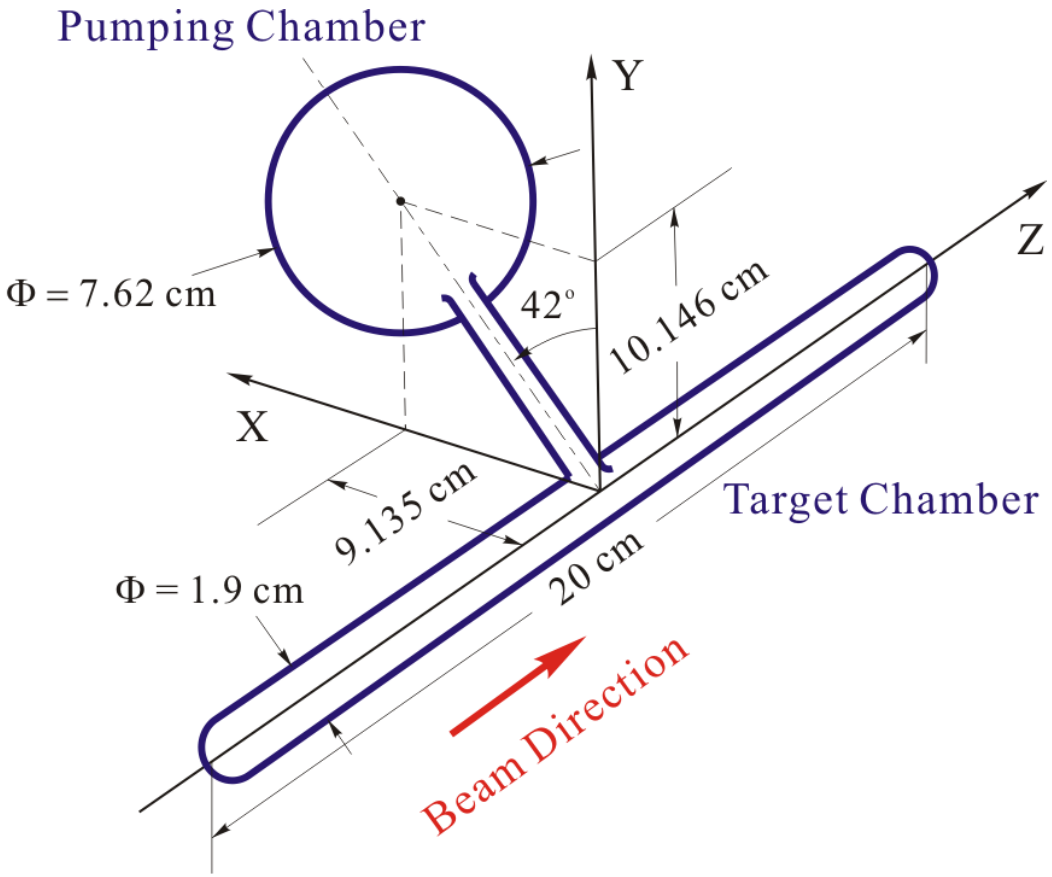
Side Effect of Shielding

- Mirror coils created by the big iron shielding add unwanted gradients.

- Simulations were carried out to calculate the total gradients generated by coils, BigBite fringe field and mirror coils.

- Average gradients were obtained at pumping chamber and target chamber to get optimum field orientation.

Cell Configuration



Best Choices of Field Orientations

Gradient (mG/cm)		dBx/dy	dBy/dz	dBz/dx	dBx/dx	dBy/dy	dBz/dz
By = 28 G	Target Chamber	0.0±1.7	10.3±1.0	11.9±0.7	11.2±1.3	2.2±0.2	-13.3±1.1
	Pumping Chamber	0.7±0.6	7.9±0.8	13.5±0.4	9.7±0.6	0.8±1.0	-10.5±0.6
By = -28 G	Target Chamber	-3.4±0.9	-18.9±0.8	11.9±0.7	11.2±1.3	2.2±0.2	-13.3±1.1
	Pumping Chamber	-4.6±0.7	-17.6±0.8	12.1±0.3	11.4±0.5	2.8±1.1	-14.2±0.9
Bx = 28 G	Target Chamber	-1.7±0.4	-4.3±0.1	18.0±1.6	15.7±5.3	4.8±2.2	-20.5±3.3
	Pumping Chamber	-2.4±1.1	-2.8±1.4	18.4±1.3	15.5±1.2	-0.8±2.1	-14.7±1.8
Bx = -28 G	Target Chamber	-1.7±0.4	-4.3±0.1	5.9±2.7	6.7±2.8	-0.5±1.8	-6.2±1.2
	Pumping Chamber	-1.5±1.2	-6.3±1.4	7.2±1.4	5.5±1.3	4.5±2.1	-10.0±1.6

Best Choices Cont.

- The best orientations of holding field are B_y = 28 G and B_x = -28 G.

- The large gradient of dB_x/dx, dB_y/dy and dB_z/dz can be corrected by existing anti-helmholtz coils of X and Z direction to less than 5 mG/cm.

- With B_y = 28 G, dB_y/dz and dB_z/dx are still quite large (10~13 mG/cm). The impact on AFP loss needs to be investigated.