

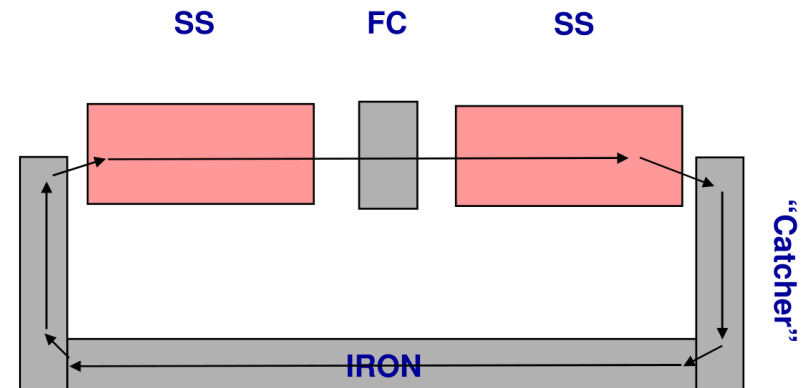
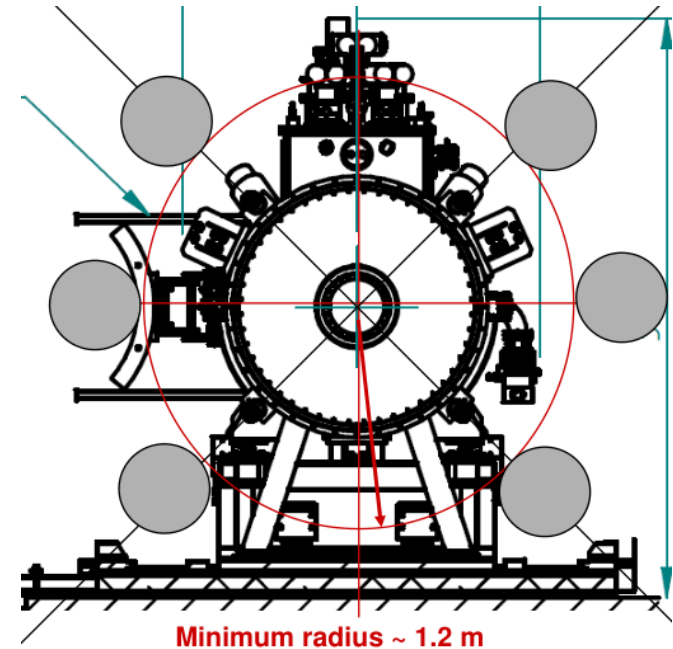
MICE Shielding

Holger Witte
Brookhaven National Laboratory
Advanced Accelerator Group

- Aim: identify single shield solution
 - one iron shield which makes shielding of individual components unnecessary
 - Initially only for Stage IV, but should also work for Stage VI (or upgradable)
- Explore shielding options
 - shield geometry probably does not fit
 - important: general principles
 - also means: need engineering effort for integration
- What has been done so far?
 - initial studies studying effectiveness of different shielding approaches (multiple bars, flux catchers, cylinders, ...)
 - effect of shielding on field of MICE
 - effect on Q9 and TOF cage

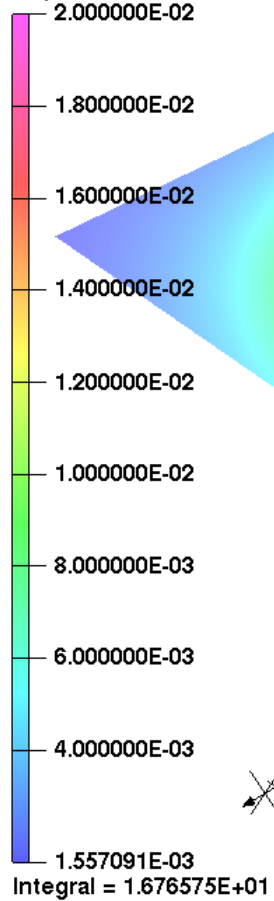
Things which don't work

- Flux return path with multiple iron bars (4/6/8/...)
 - poor shielding performance (~2)
 - reason: large gaps between bars allows flux to escape
 - gets slightly better with increase in diameter and number of bars
- Flux catchers / end caps (in combination with bars)
 - catch only (some) flux from spectrometer

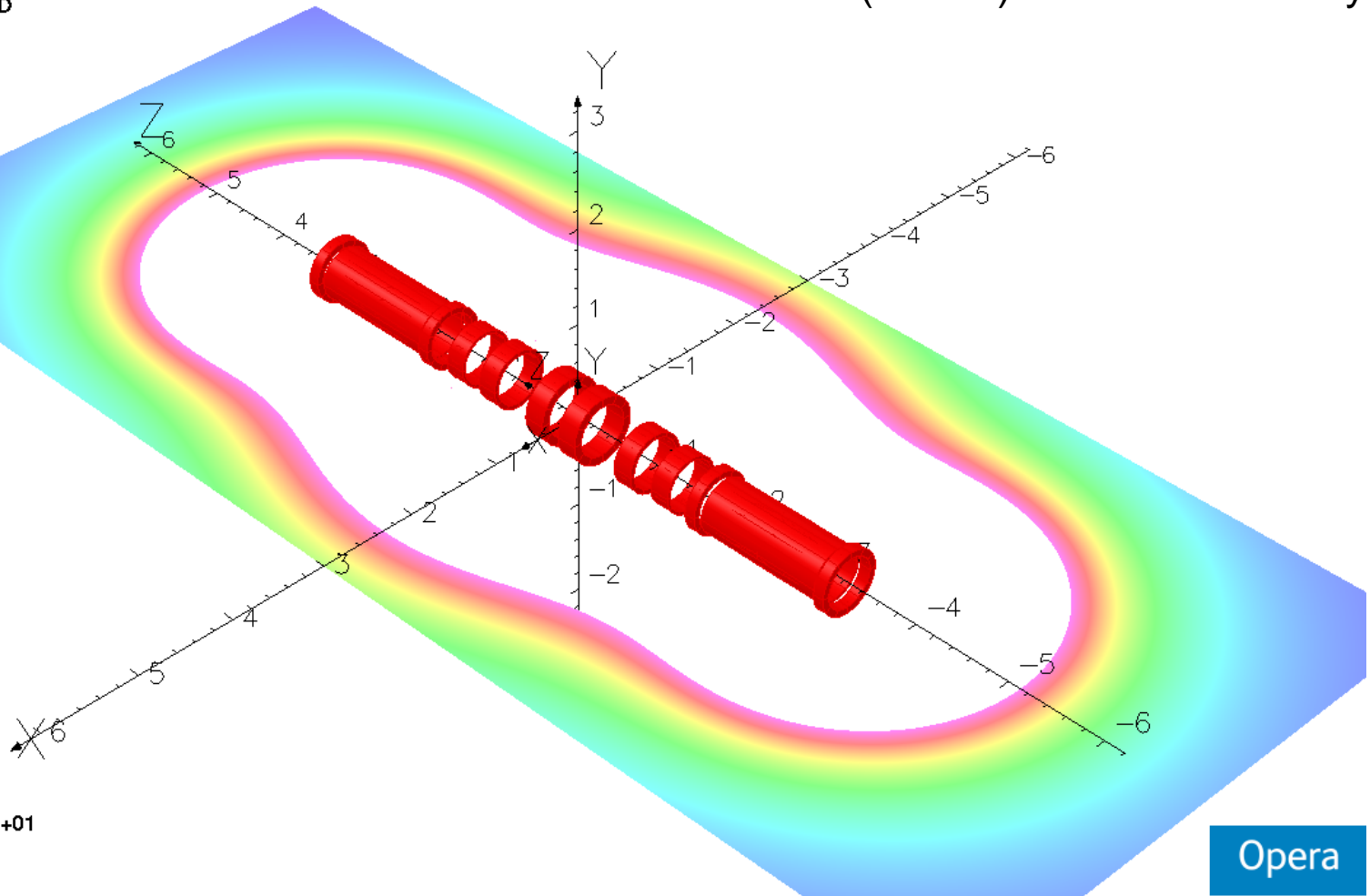


Initial Fields

Map contours: BMOD



200 Gauss (20 mT) Line: >2m radially



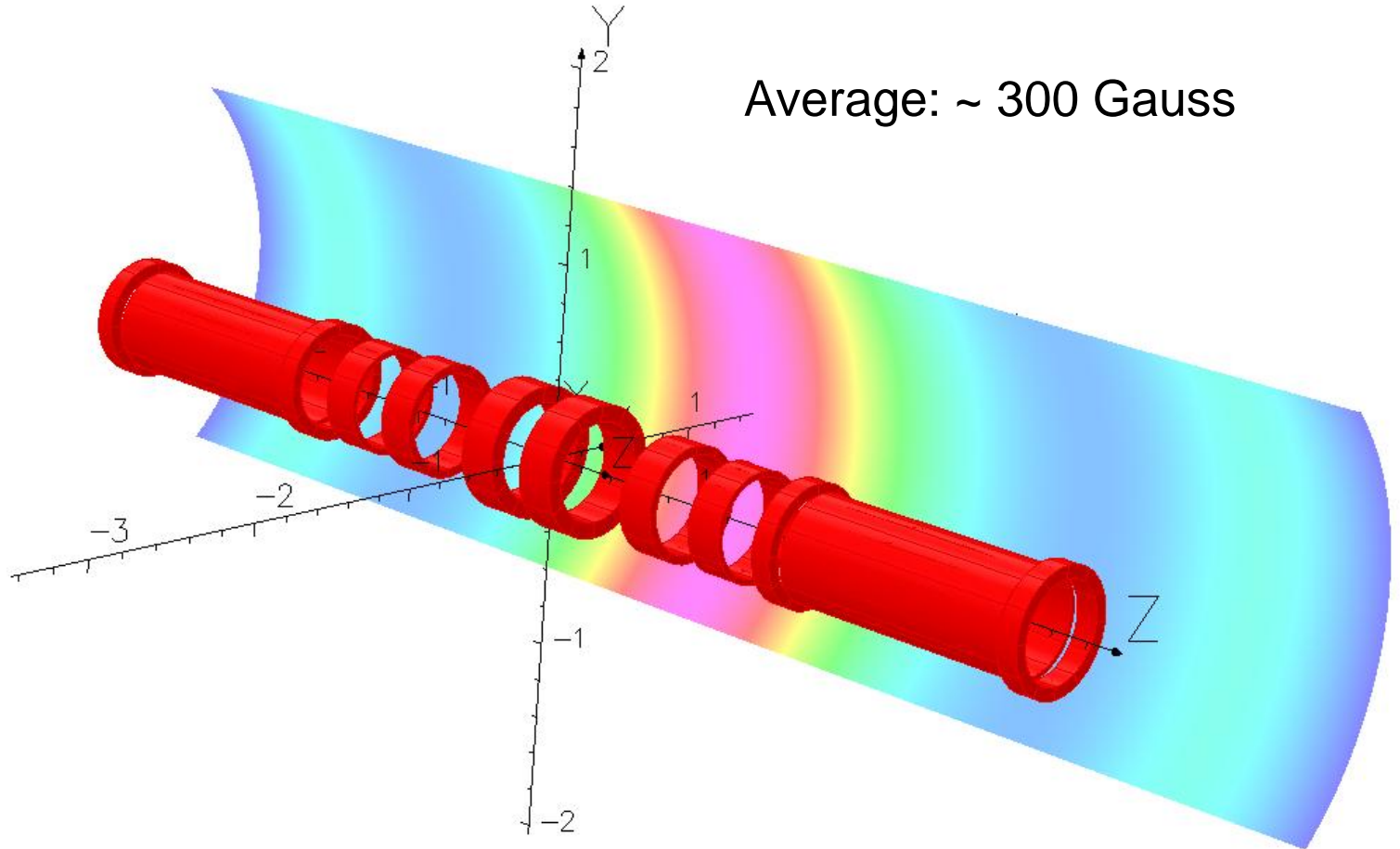
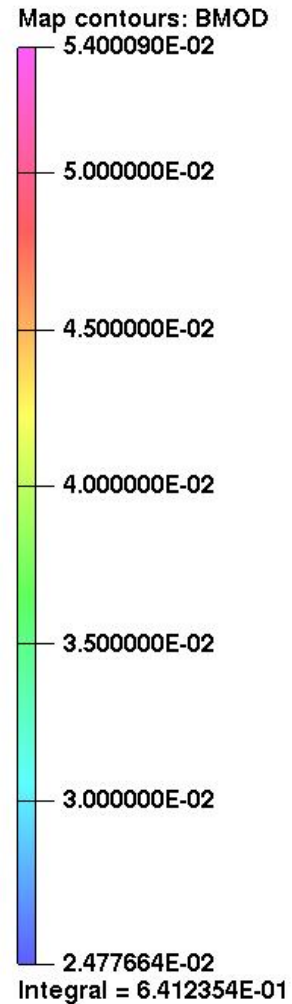
Simulation: Stage IV, 200 MeV flip, no iron

Initial Fields

1/Aug/2012 13:53:29

Peak: 550 Gauss at $r=1.5\text{m}$

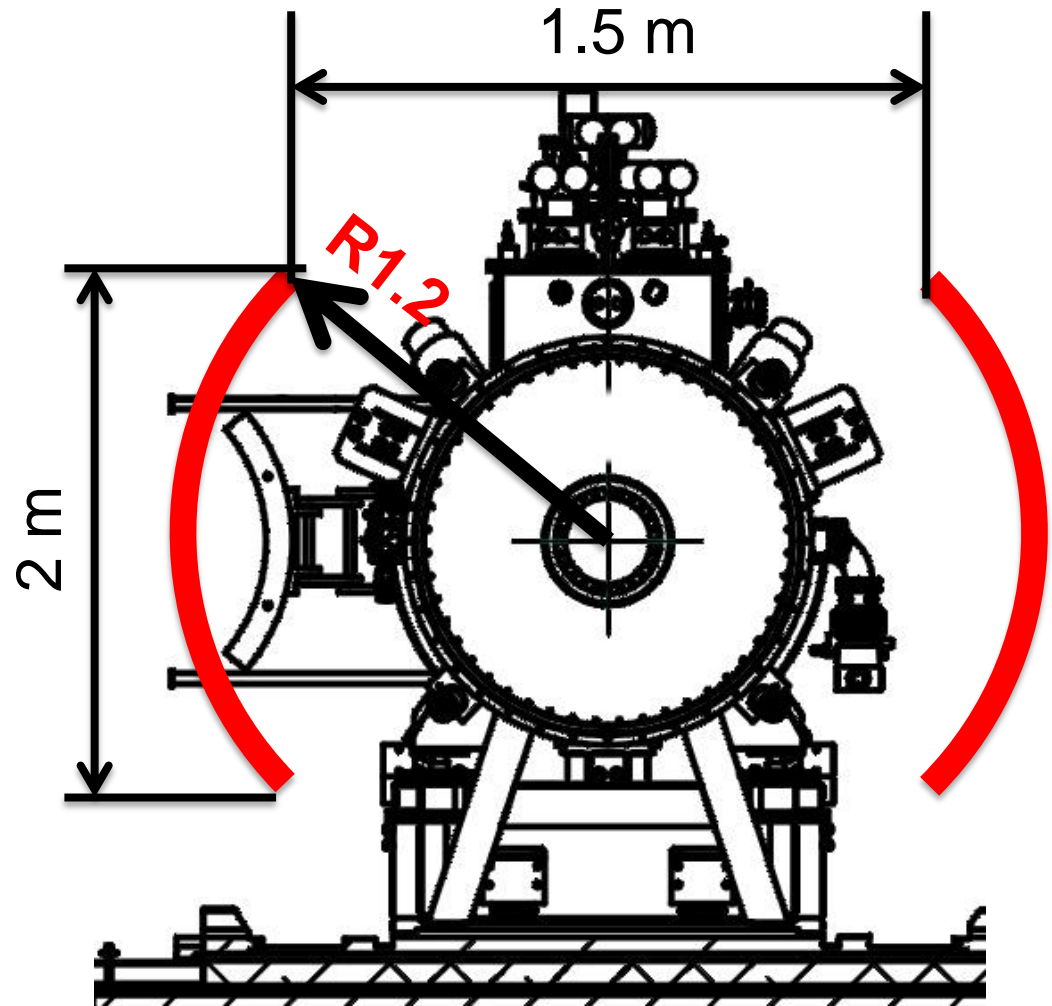
Average: ~ 300 Gauss



Opera

Quarter Tubes

- (Note: not to scale)
- To get good shielding horizontally: need continuous steel in azimuthal direction
- Geometry
 - Tube of radius 1.2 m
 - wall thickness 10 cm
 - hor. cut-out of 1.5 m
 - Length: 9 m
- breaks symmetry, will come back to this later



Magnetization

27/Jul/2012 18:32:12

Surface contours: BMOD

1.403507E+00

1.200000E+00

1.000000E+00

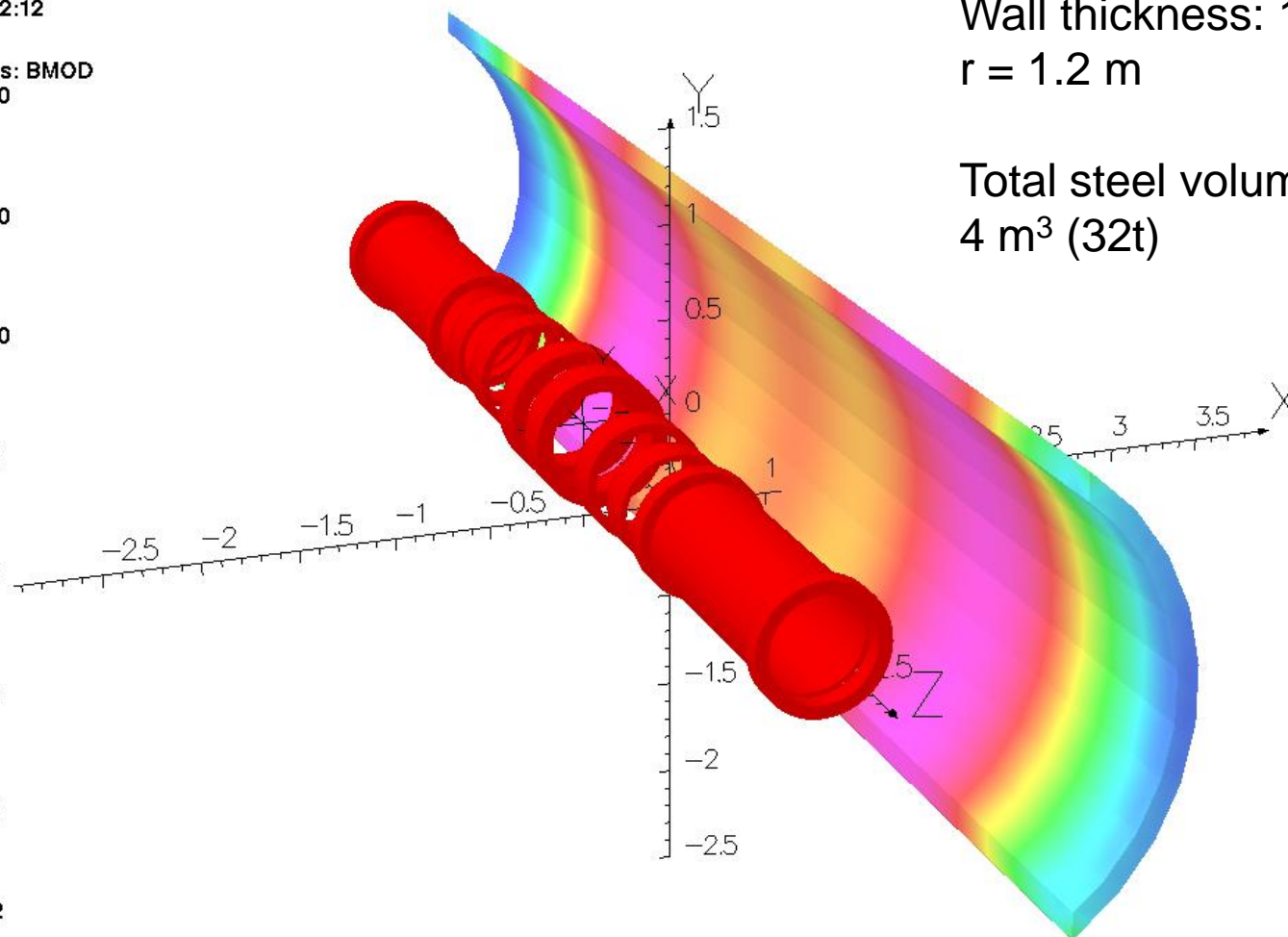
8.000000E-01

6.000000E-01

4.000000E-01

2.000000E-01

3.523426E-02

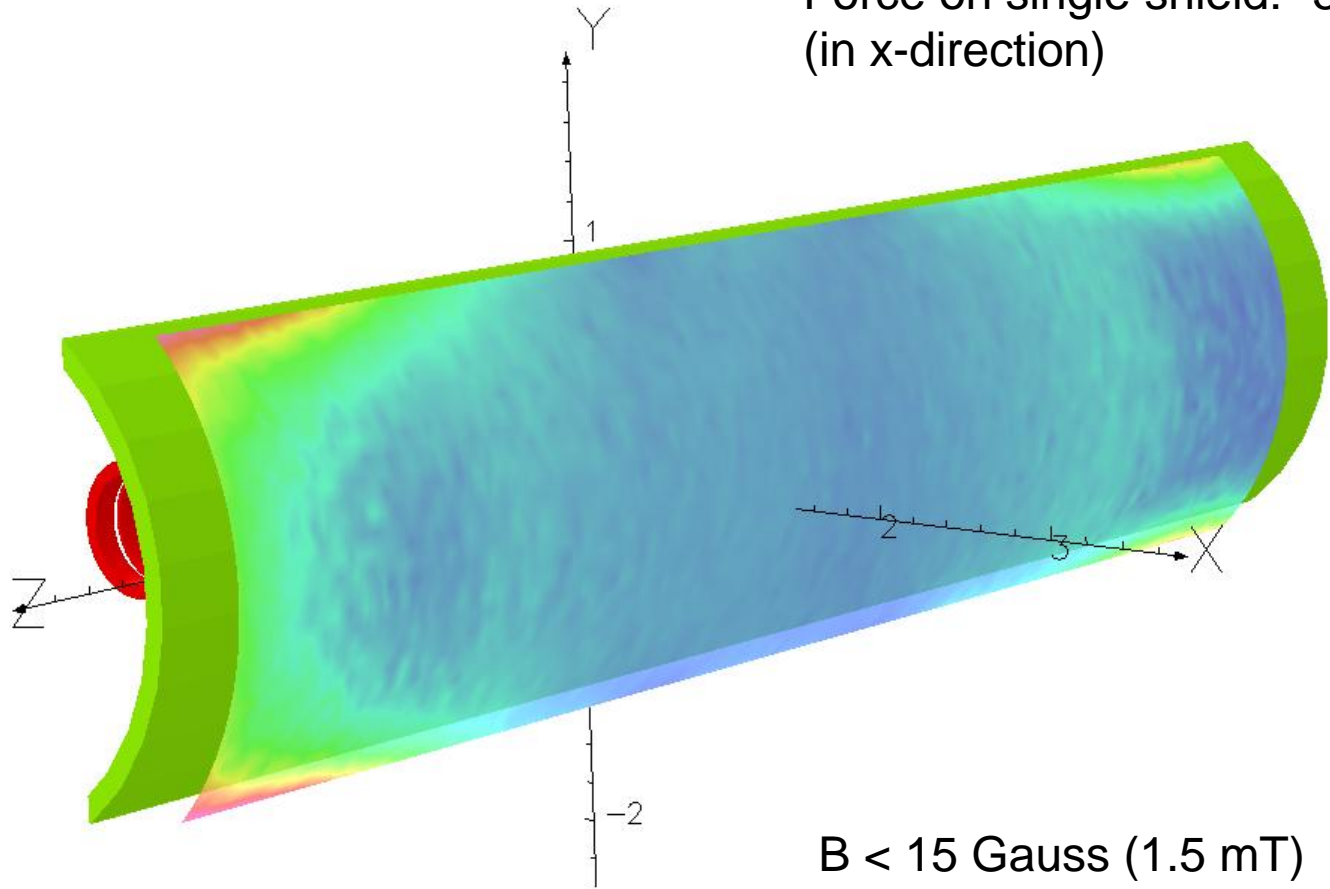
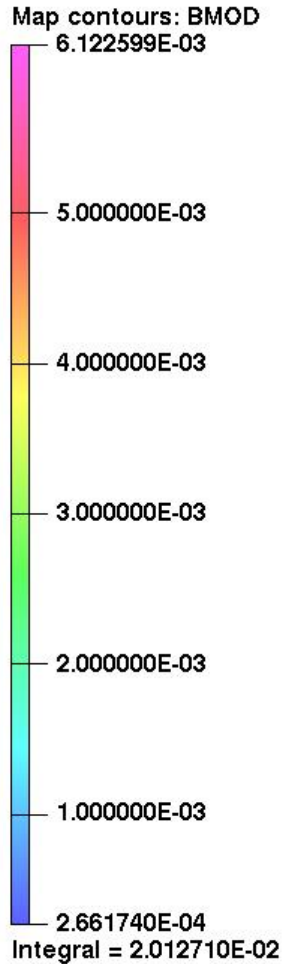


Wall thickness: 10 cm
 $r = 1.2 \text{ m}$

Total steel volume:
 4 m^3 (32t)

Step IV, 240 MeV, Flip

27/Jul/2012 18:33:16



Force on single shield: -36 kN
(in x-direction)

B < 15 Gauss (1.5 mT)

240 MeV/c

Development of Fringe Field

31/Jul/2012 17:37:41

Map contours: BMOD

8.119838E-03

7.000000E-03

6.000000E-03

5.000000E-03

4.000000E-03

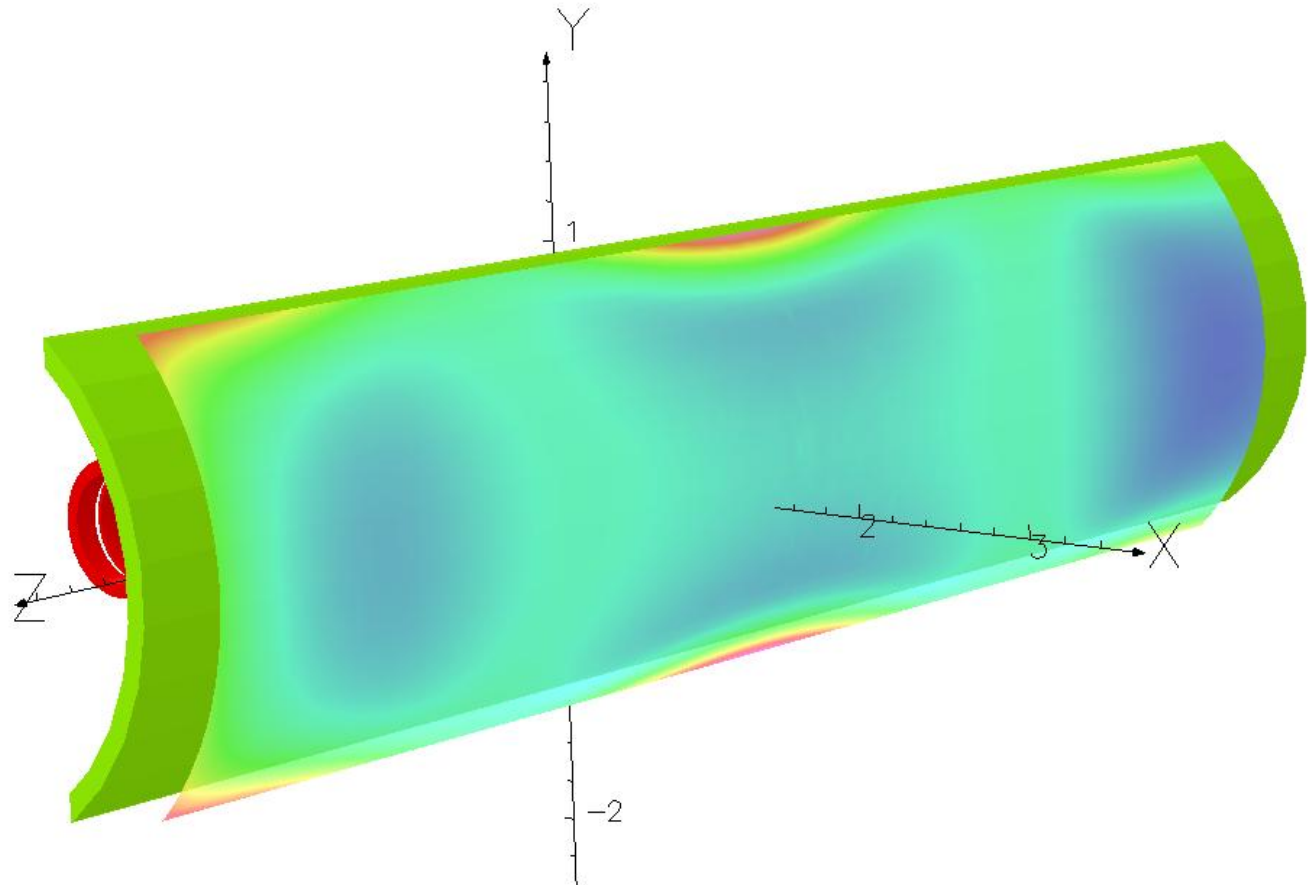
3.000000E-03

2.000000E-03

1.000000E-03

5.080608E-04

Integral = 3.928560E-02

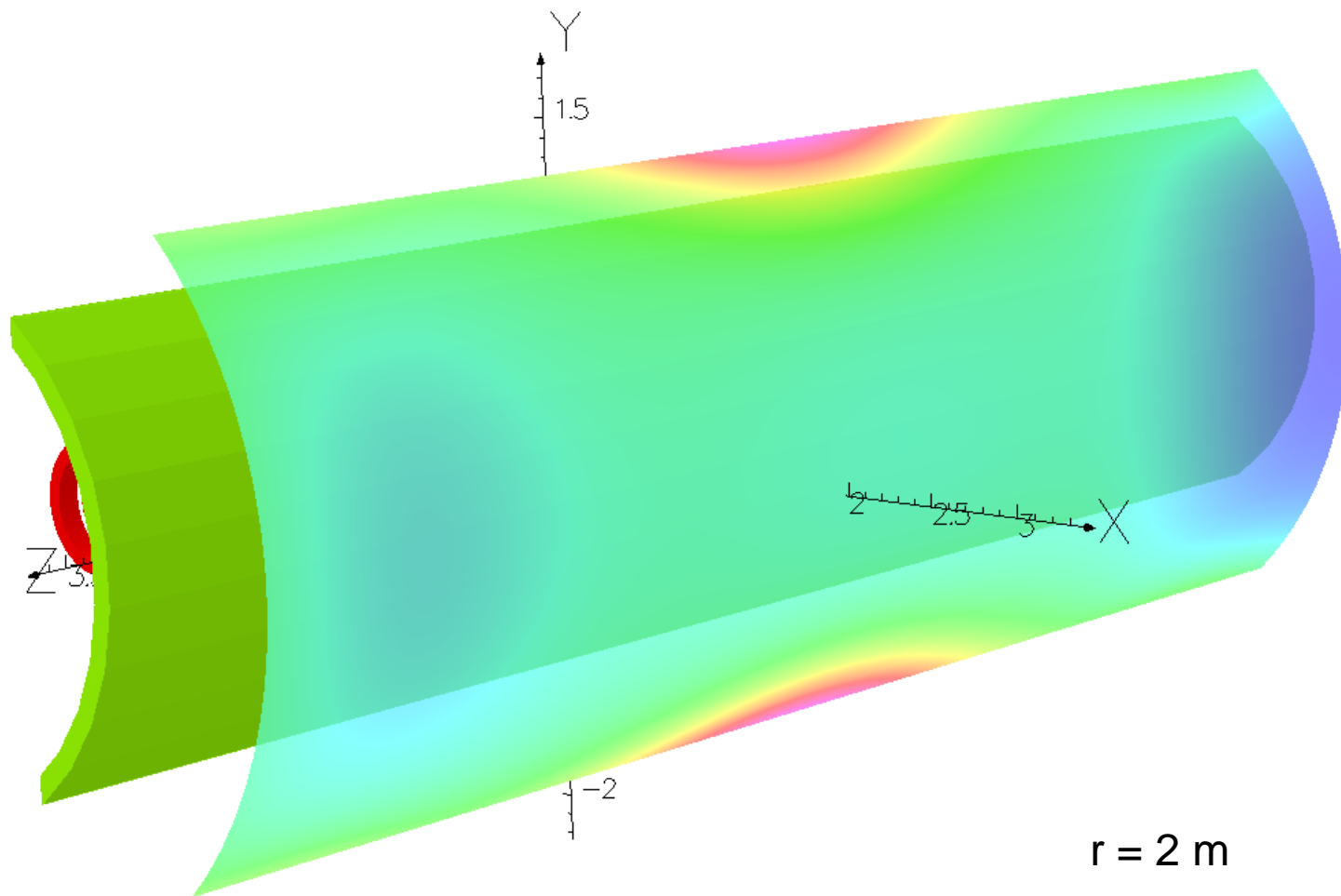
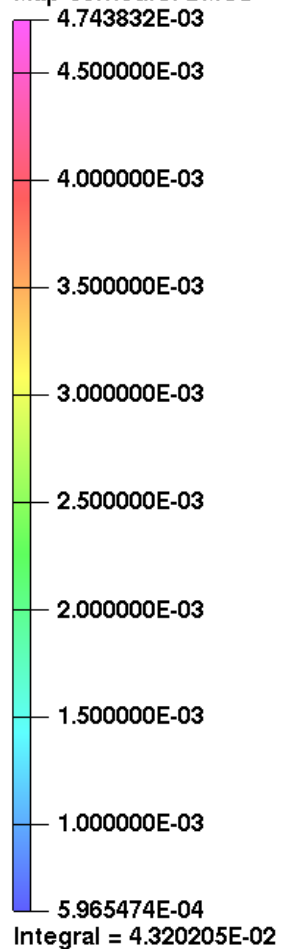


$r = 1.5 \text{ m}$

Development of Fringe Field

31/Jul/2012 17:39:37

Map contours: BMOD



Development of Fringe Field

31/Jul/2012 17:40:07

Map contours: BMOD

1.904446E-03

1.800000E-03

1.600000E-03

1.400000E-03

1.200000E-03

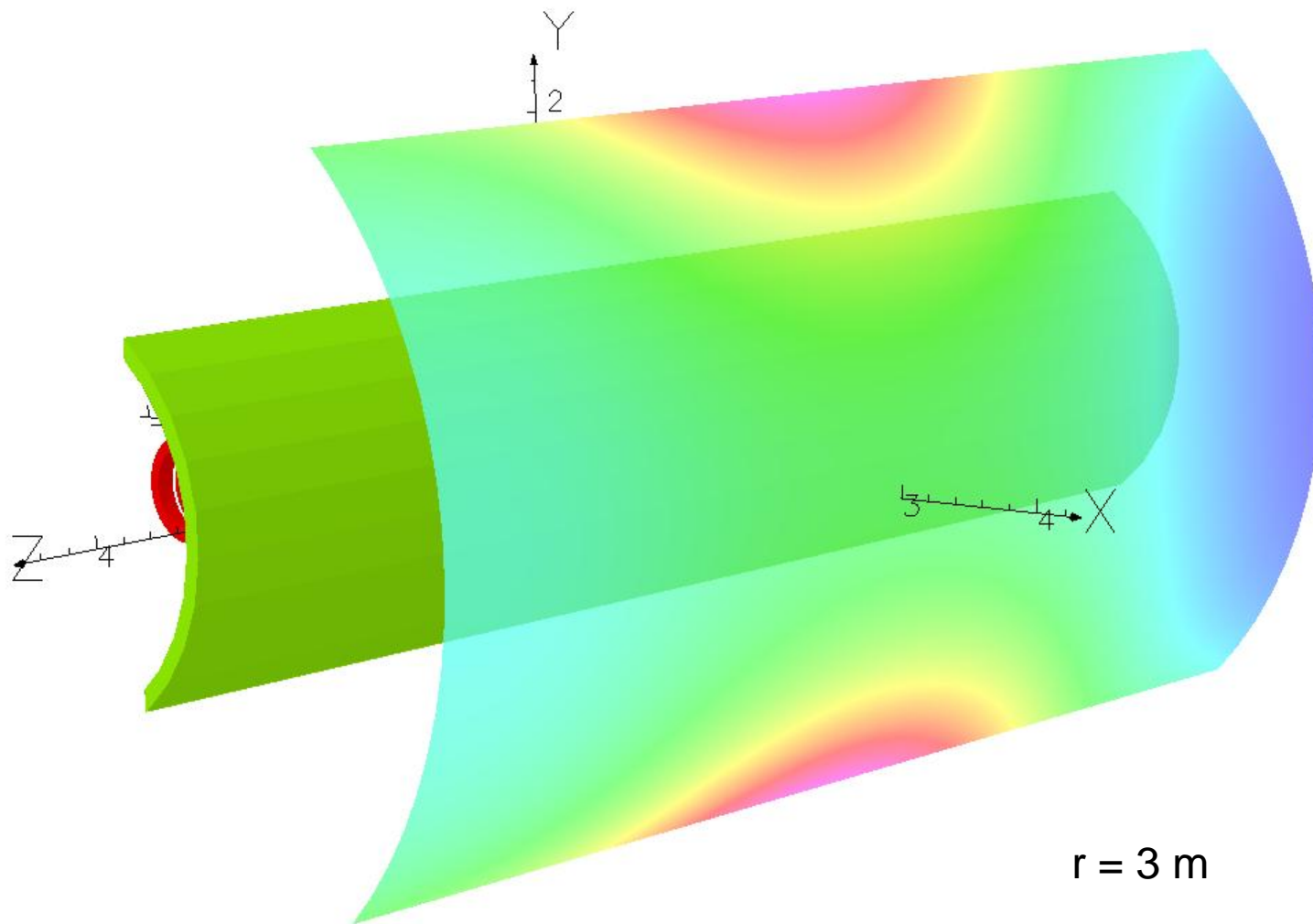
1.000000E-03

8.000000E-04

6.000000E-04

4.573548E-04

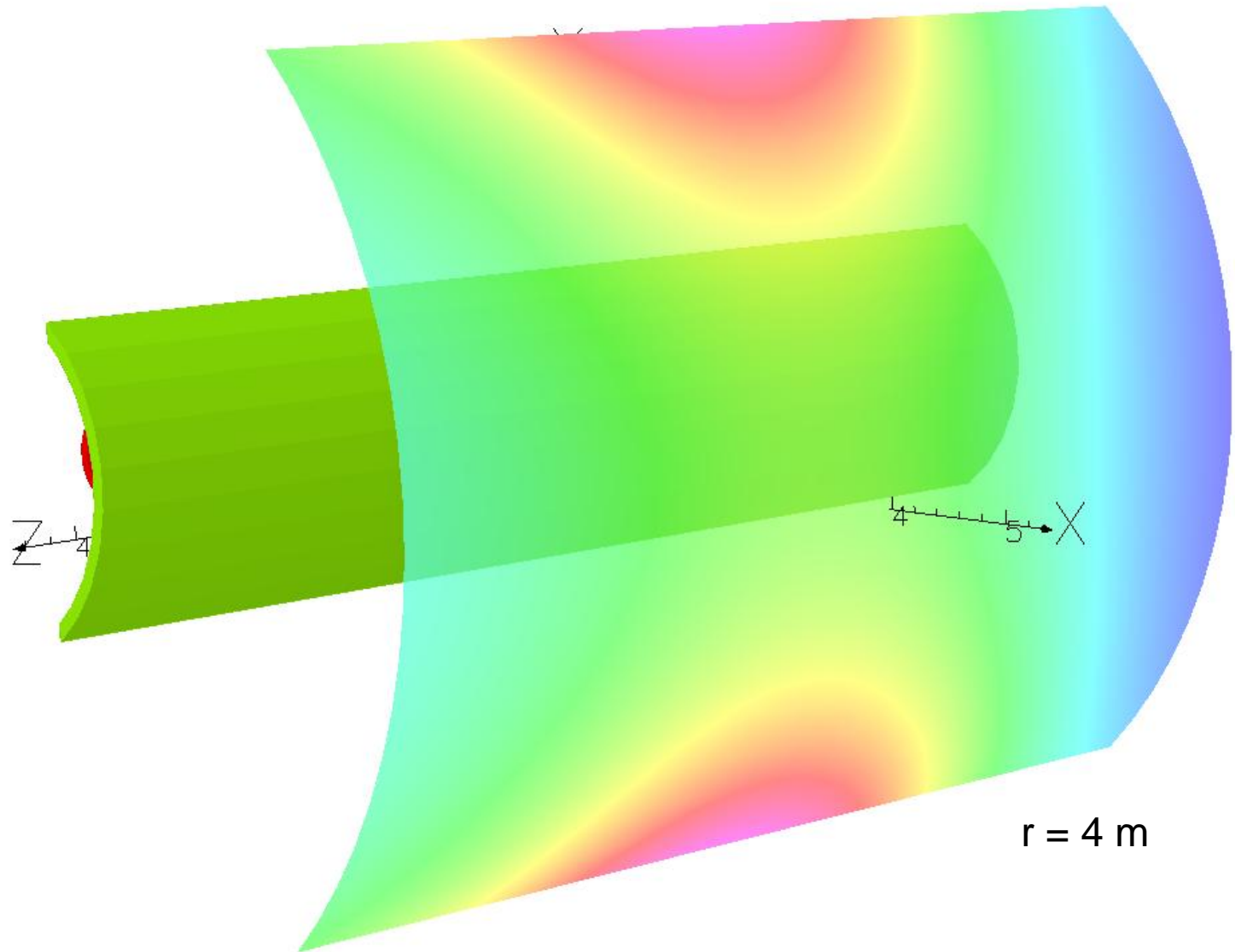
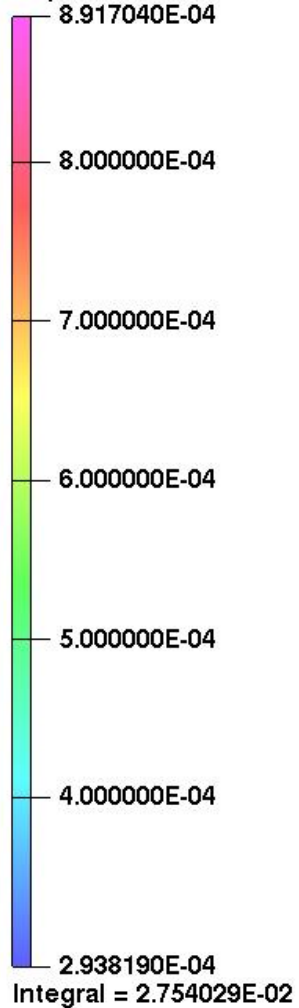
Integral = 3.685108E-02



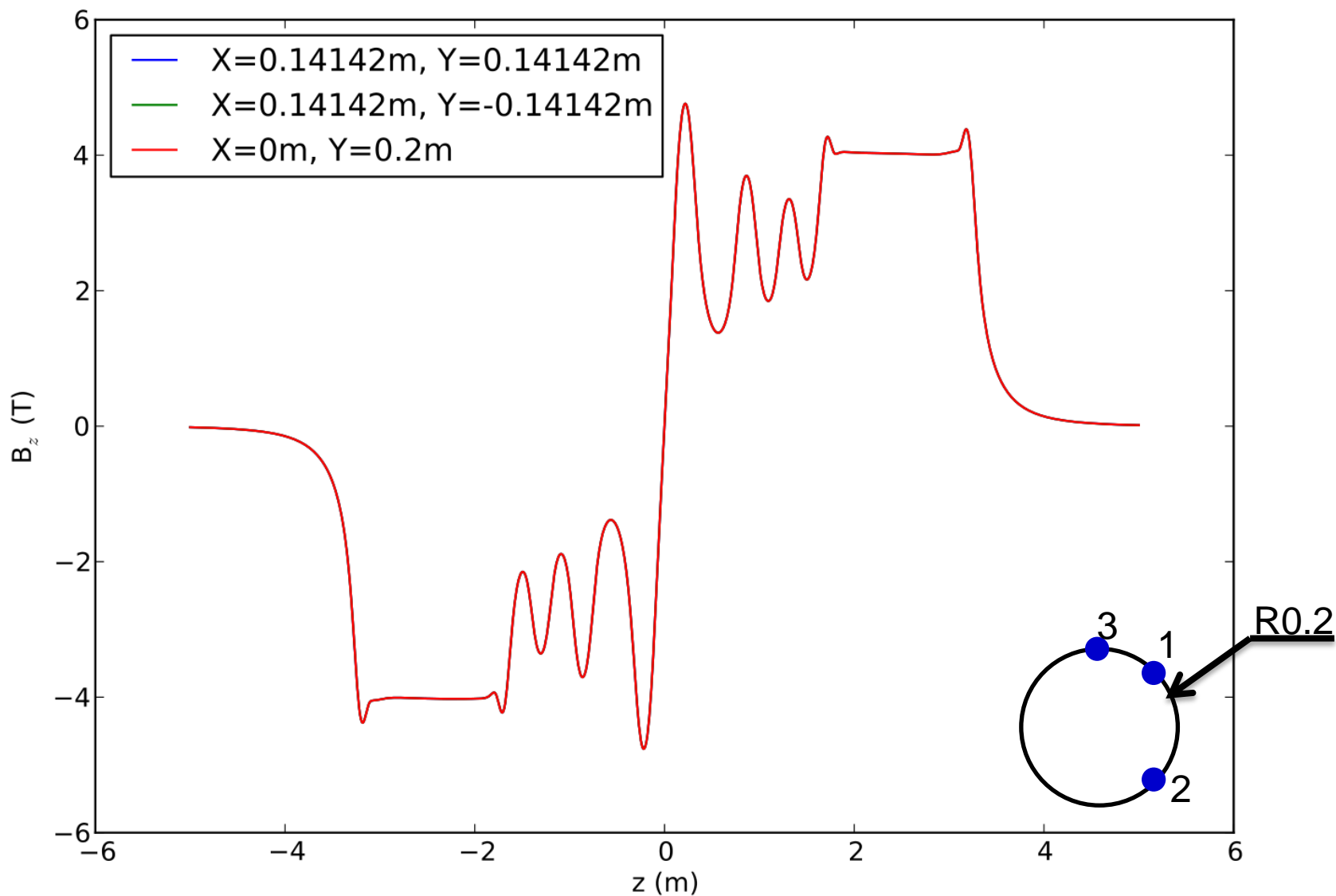
Development of Fringe Field

31/Jul/2012 17:40:39

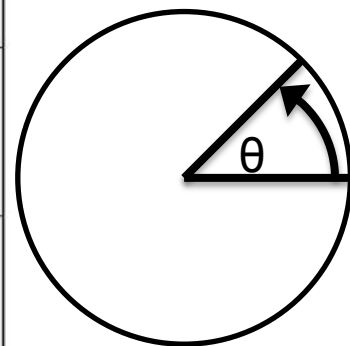
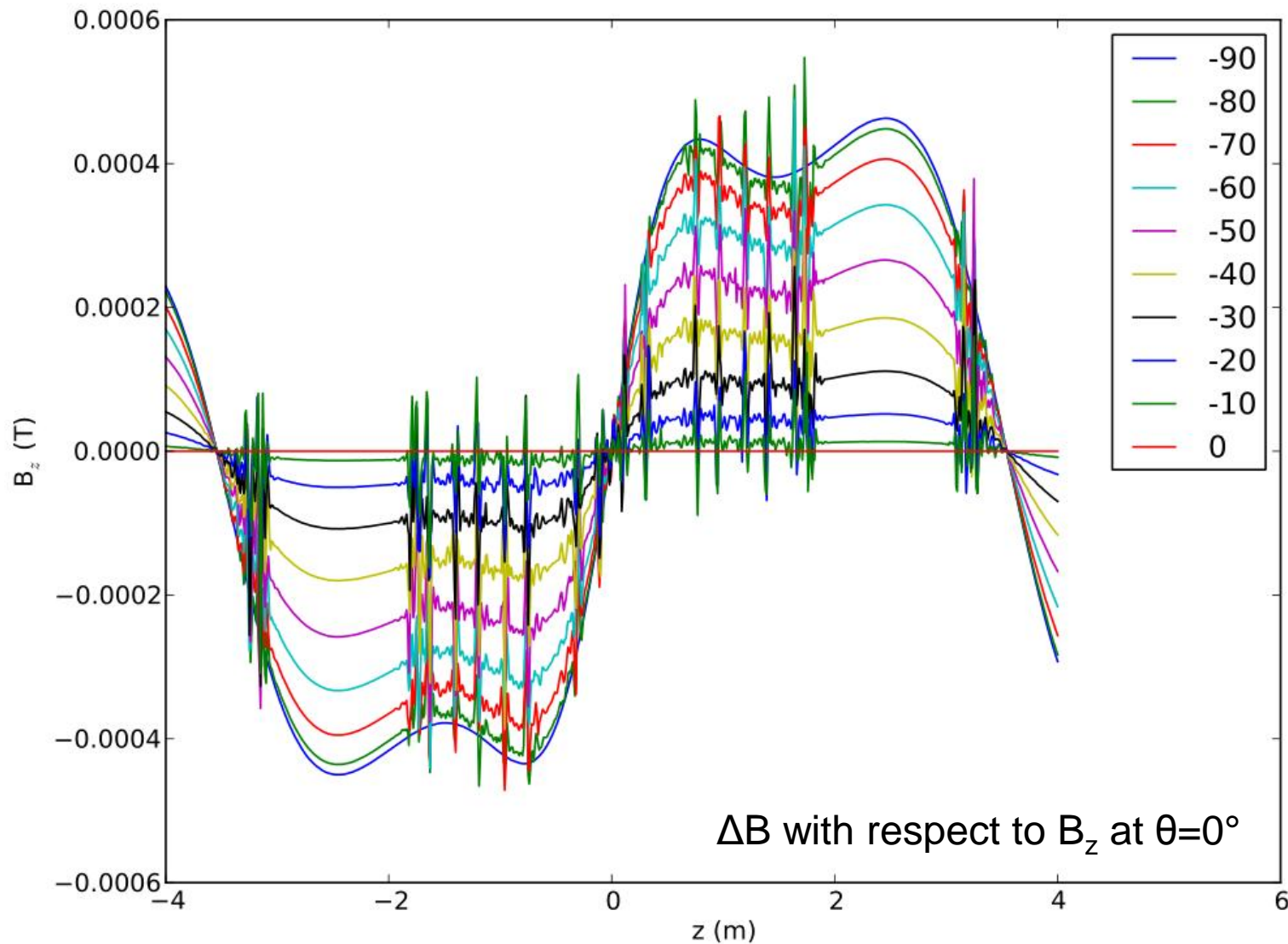
Map contours: BMOD



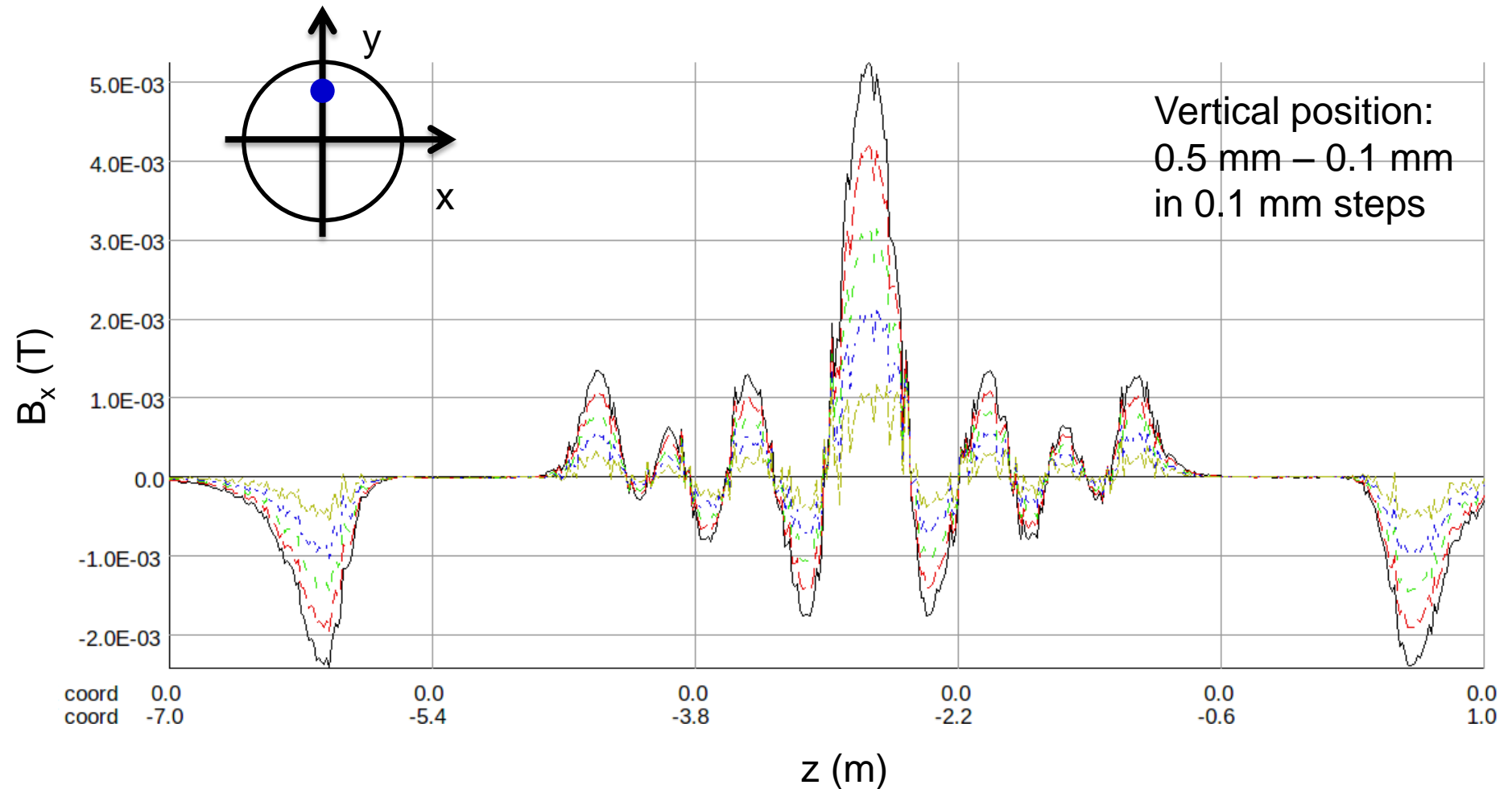
Effect on Field in Channel



Effect on Field in Channel

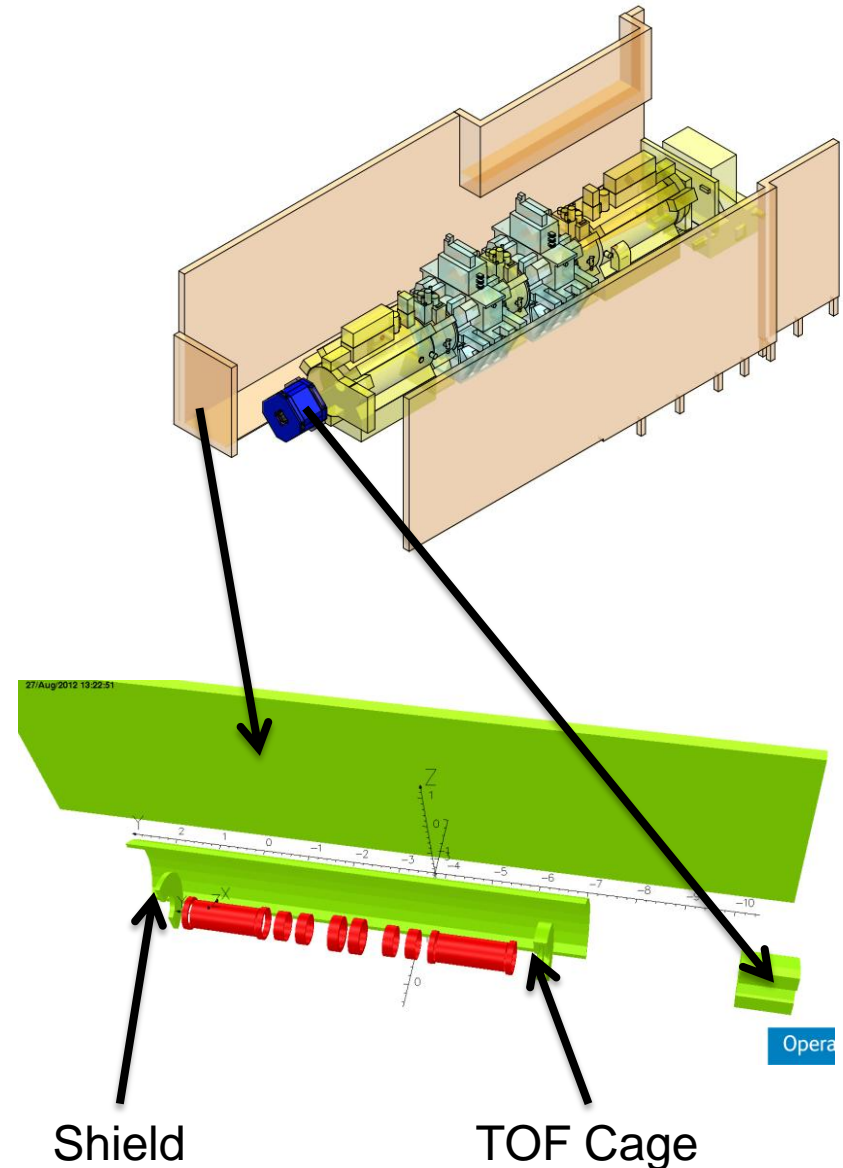


Effect of Shield on Field



Additional Iron Structures

- Additions:
 - ‘Virostek’ shields
 - TOF cage
 - Quad Q9
- Geometry: SAT file from Jason Tarrant
- Geometry simplifications
 - Q9: ignore pole faces
 - walls: simple plates hor. 4m away on either side

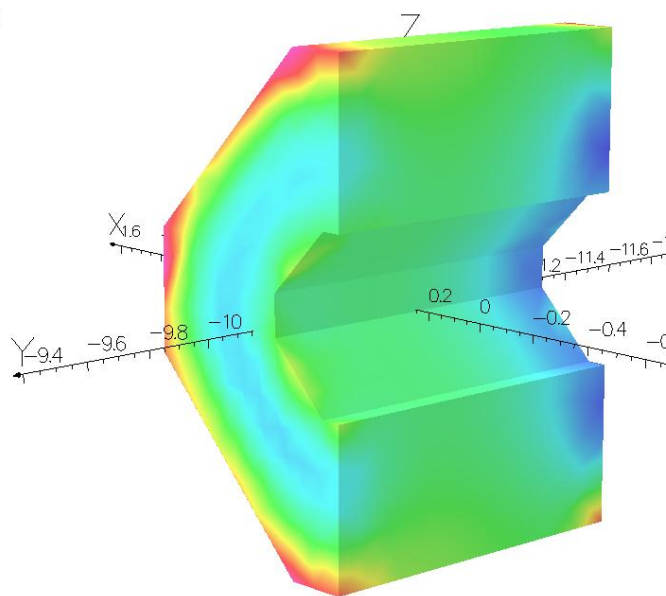
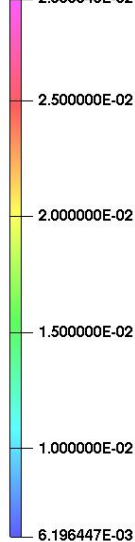


Quad Q9

No Shield: 15mT

21/Aug/2012 13:45:41

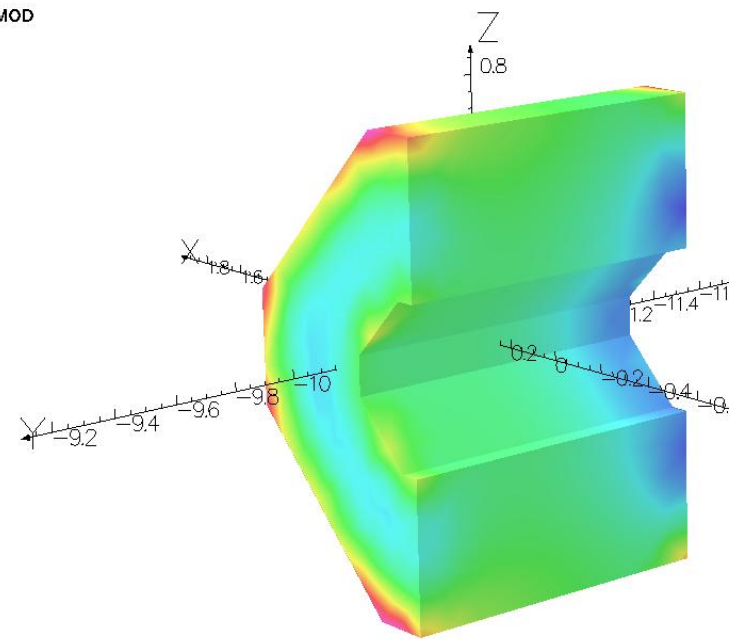
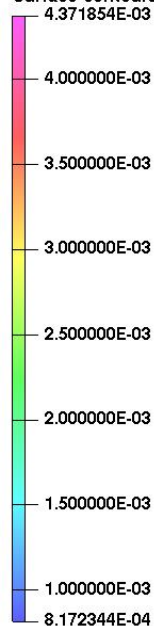
Surface contours: BMOD
2.936649E-02



Shield: 2.5 mT

21/Aug/2012 13:45:56

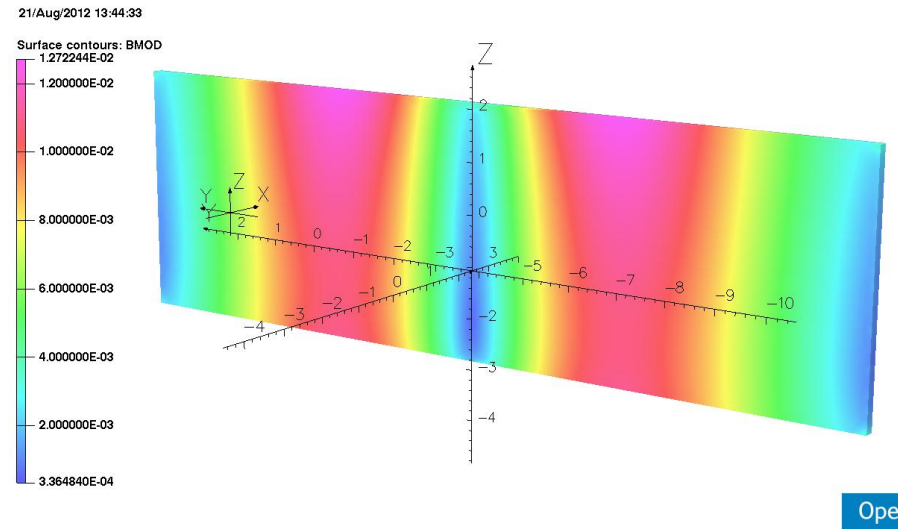
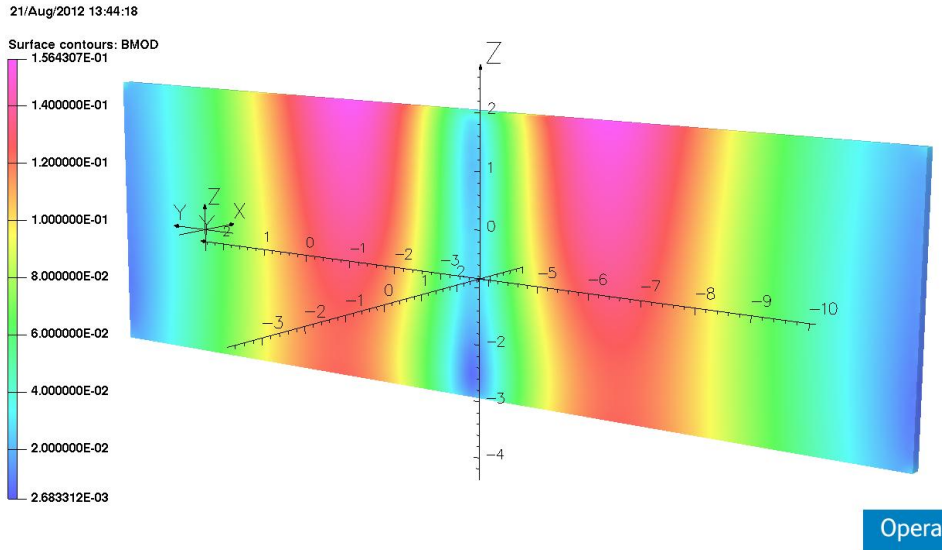
Surface contours: BMOD



Reduction of factor 7

No Shield: 150 mT (peak)

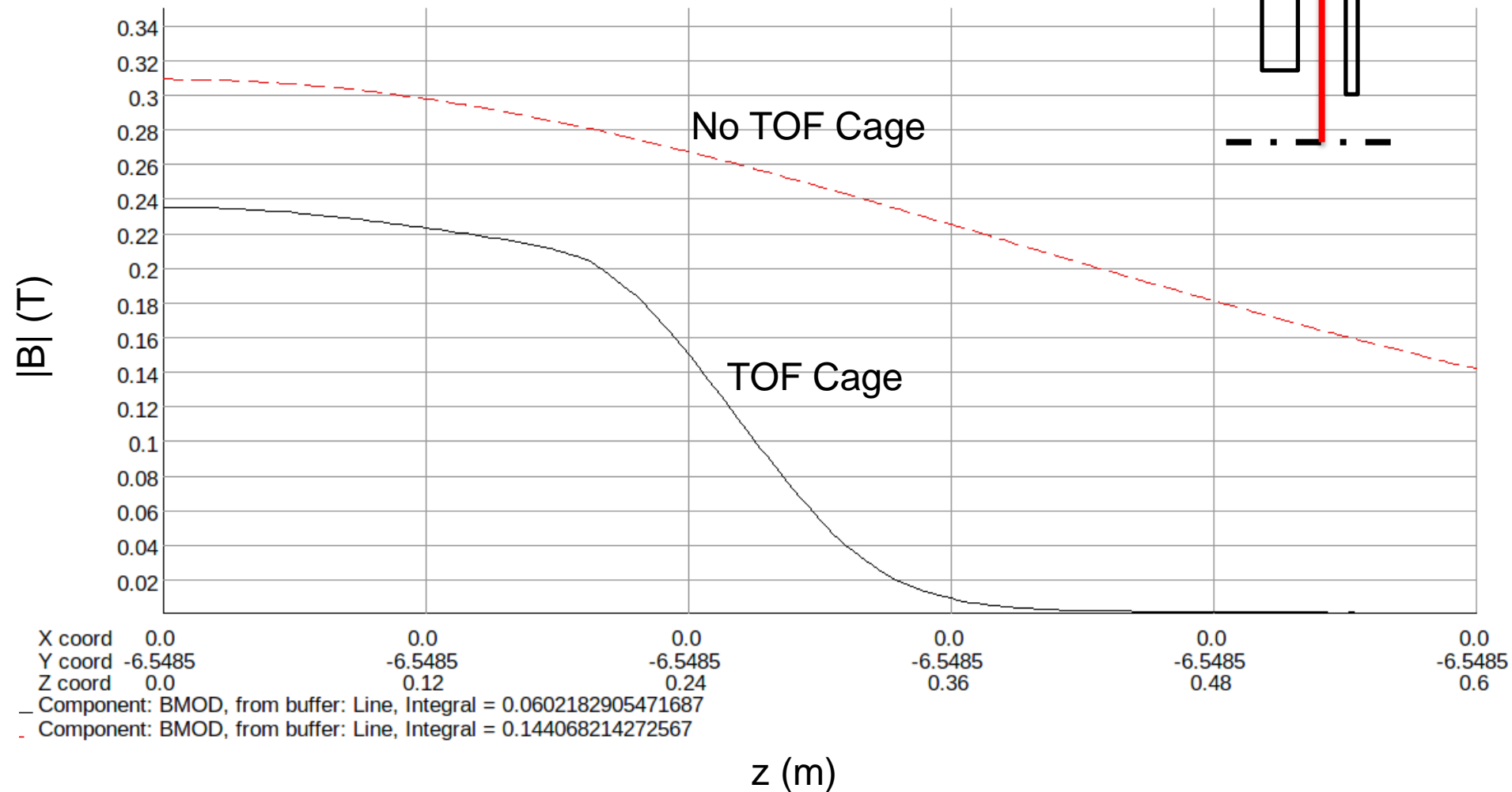
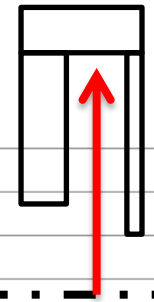
Shield: 12 mT (peak)



Reduction of factor 10+

Field in TOF Cage

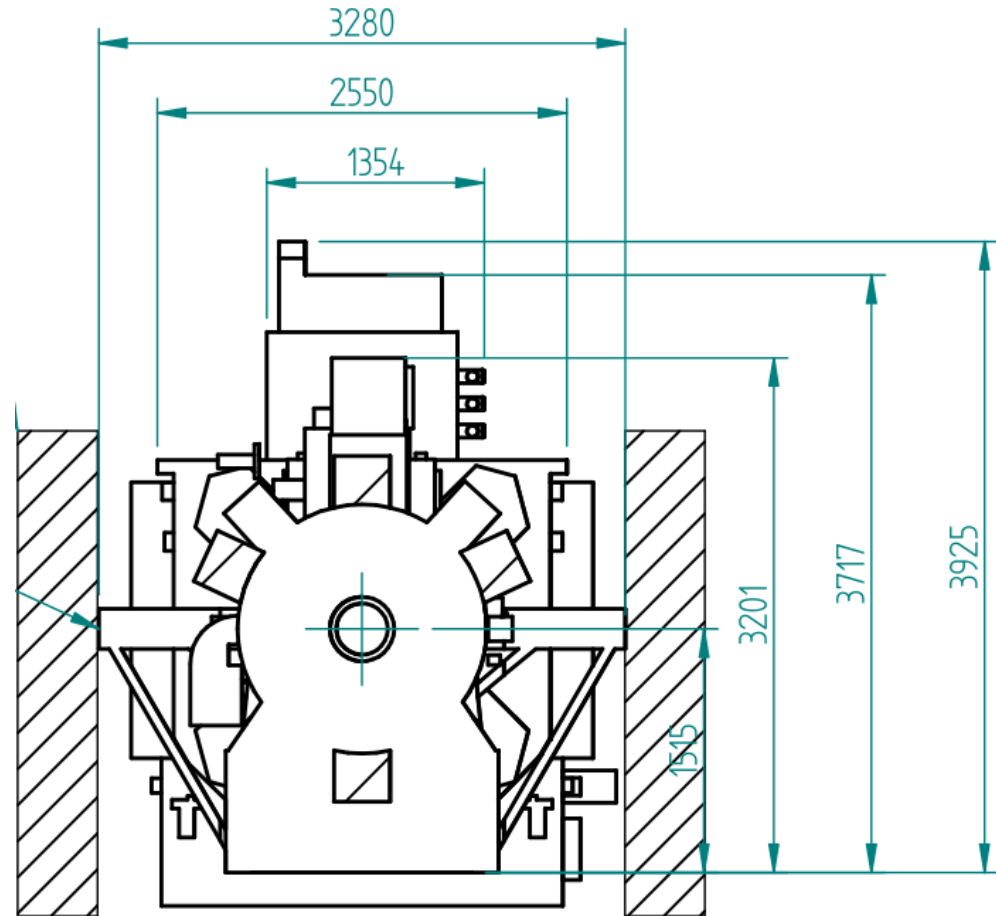
Aug/2012 13:28:00



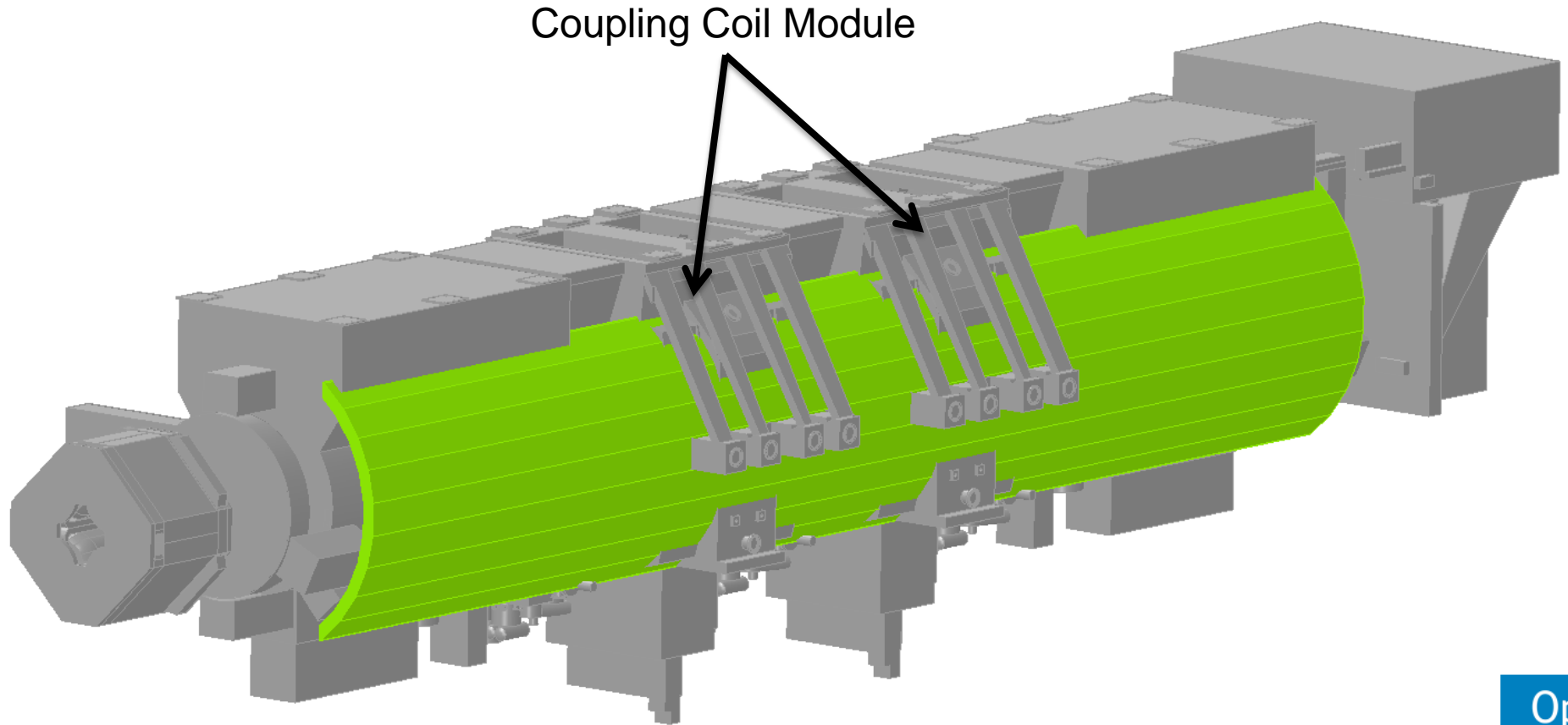
Options for Extension MICE

Stage VI

- MICE stage VI:
significantly larger in diameter
 - Coupling coils
 - RF waveguides
- Adaption of scheme possible?
- Ideally:
 - single scheme for both scenarios
 - Or: possibility of modification



MICE Stage VI

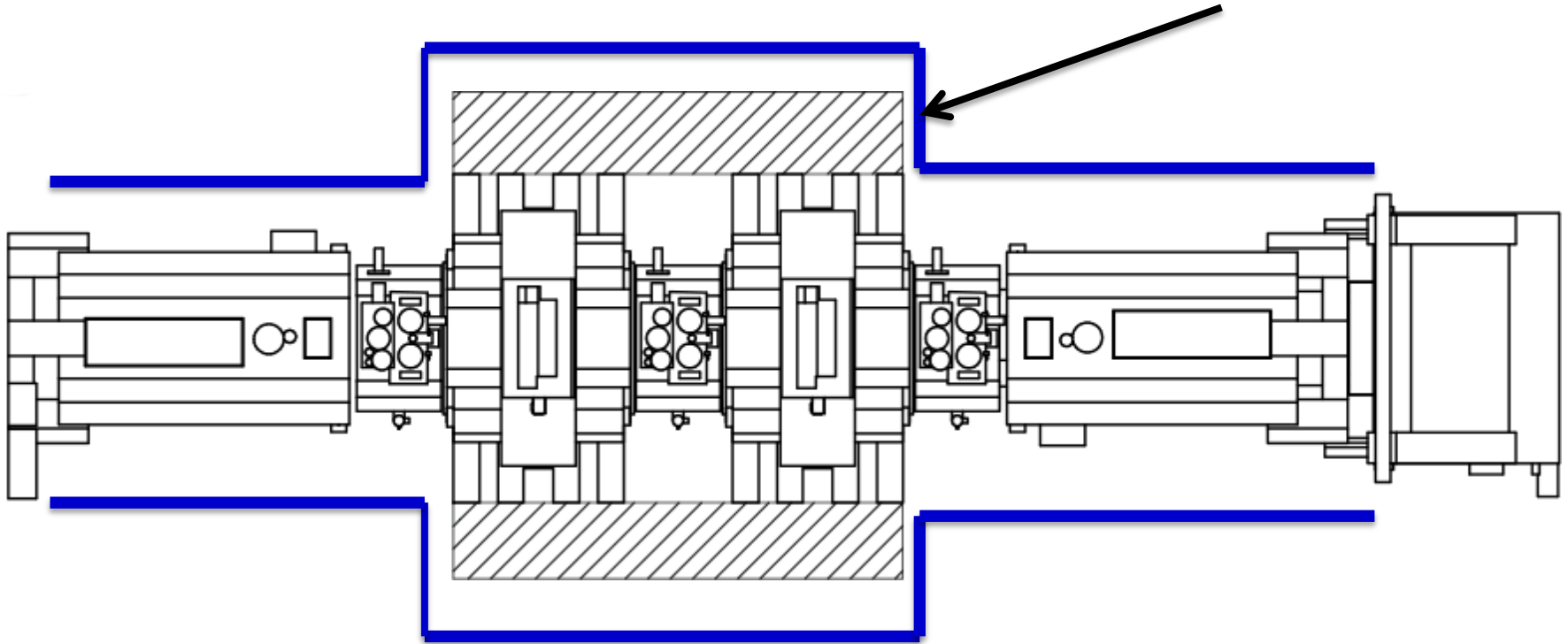


Op

MICE Stage VI CAD file provided by Jason Tarrant

MICE Stage VI – Option 1

Required: closed iron surface
in long. direction



MICE Stage VI – Option 1

2/Aug/2012 14:50:22

Map contours: BMOD

3.201088E-03

3.000000E-03

2.500000E-03

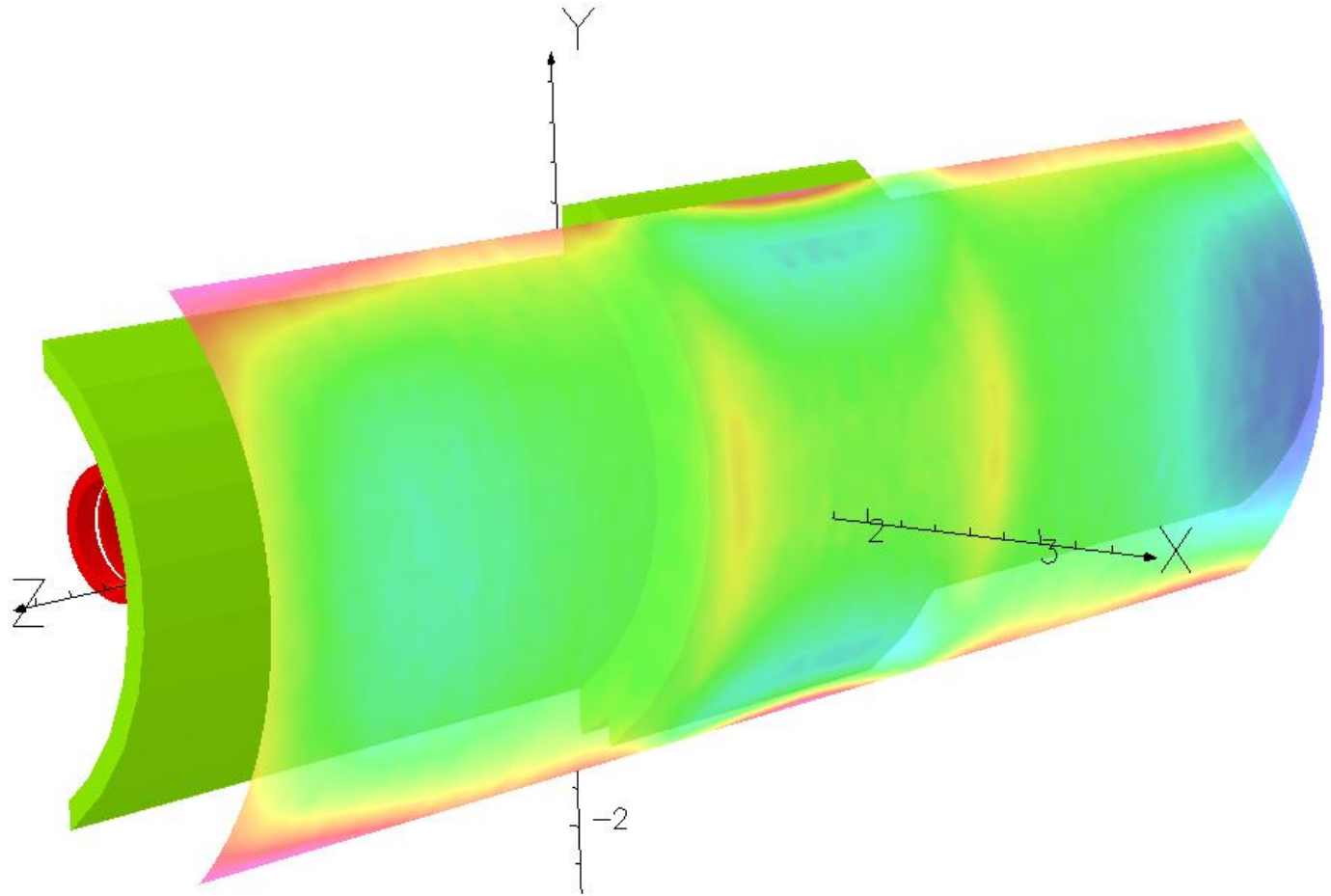
2.000000E-03

1.500000E-03

1.000000E-03

5.304285E-04

Integral = 3.594607E-02

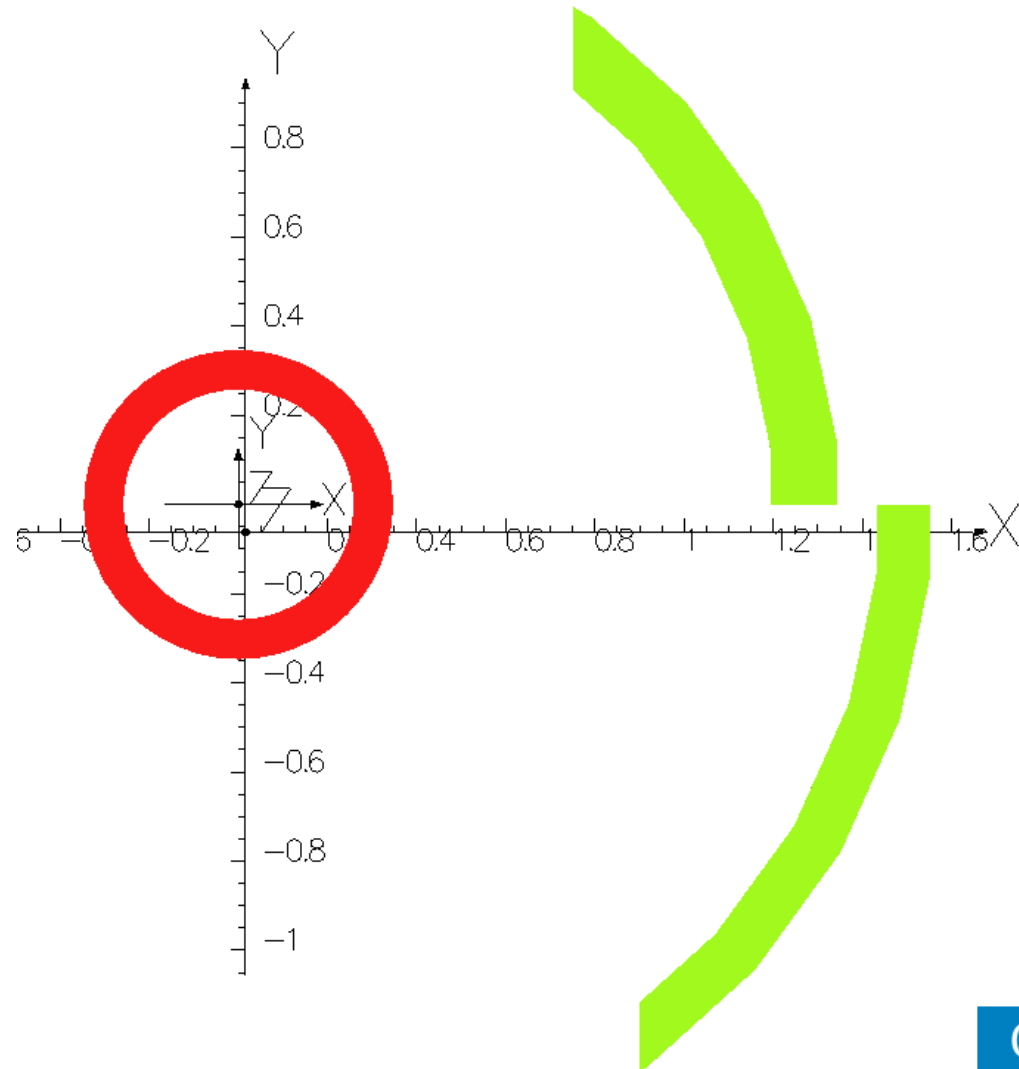


$r=1.5\text{m}$



MICE Stage VI – Option 2

- Gap in radial direction
 - still continuous flux return path in longitudinal direction
- Nesting of tubes of different diameter
 - azimuthal angles must match
 - overlap seems not necessary
- Allows feed-in/out of tracker wiring?



MICE Stage VI – Option 2

6/Aug/2012 13:59:37

Map contours: BMOD

8.667650E-03

8.000000E-03

7.000000E-03

6.000000E-03

5.000000E-03

4.000000E-03

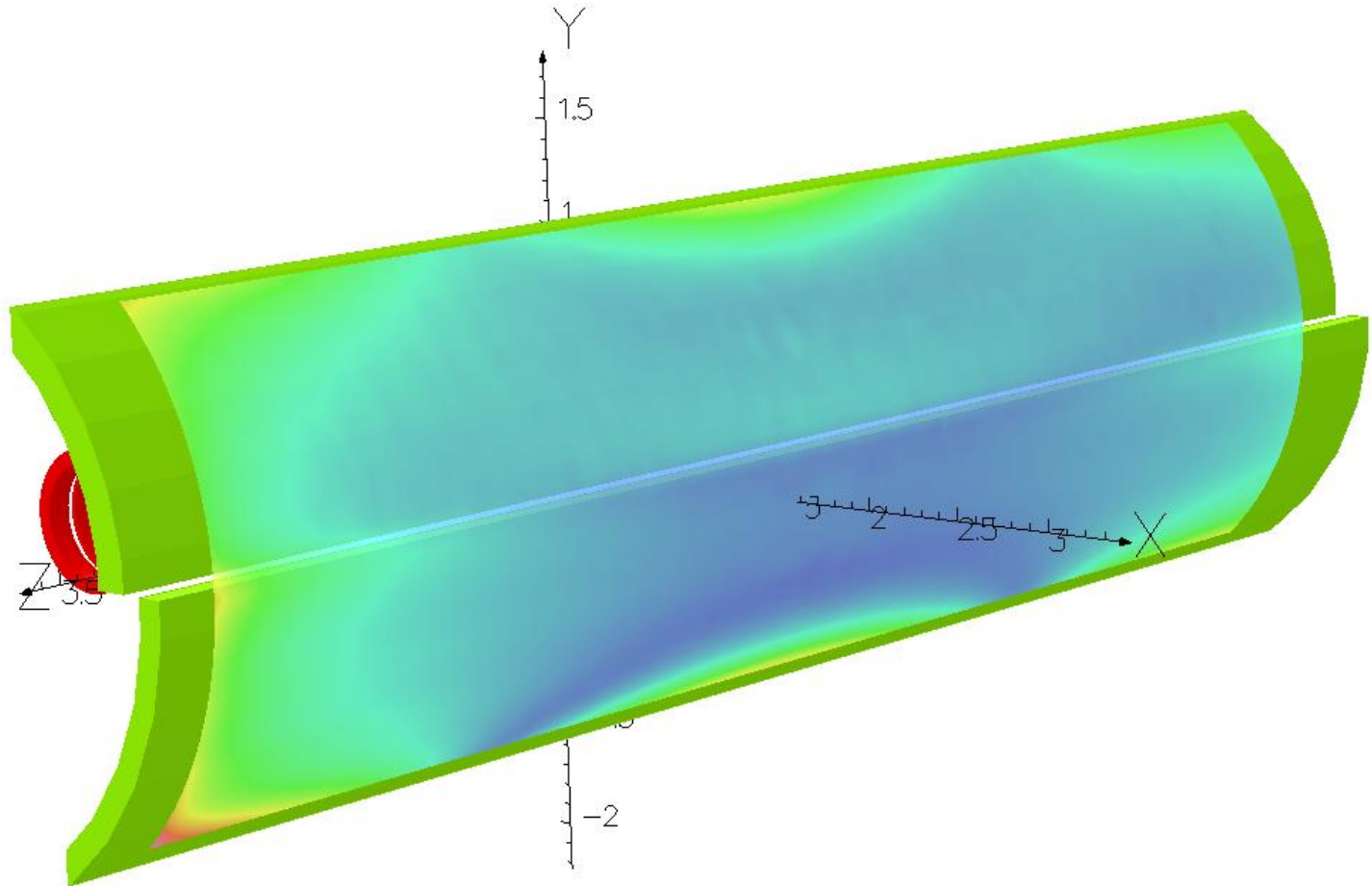
3.000000E-03

2.000000E-03

1.000000E-03

1.610120E-04

Integral = 2.959034E-02



Opera

- Things which don't work:
 - several iron bars around MICE
 - flux catchers
- Quarter tubes covering $\pm 50^\circ$ look promising
 - for all cases of Stage IV, not only 200 MeV flip mode
 - B less than 15 Gauss (shielding factor 30)
 - forces manageable?
 - effect on central field small (small enough?)
- Stage VI: options for possible modification of scheme
 - provide continuous longitudinal flux path
 - cover all azimuthal angles (jumps in radial direction seem ok)