Experiment in a bottle (magnetic): MICE PRY

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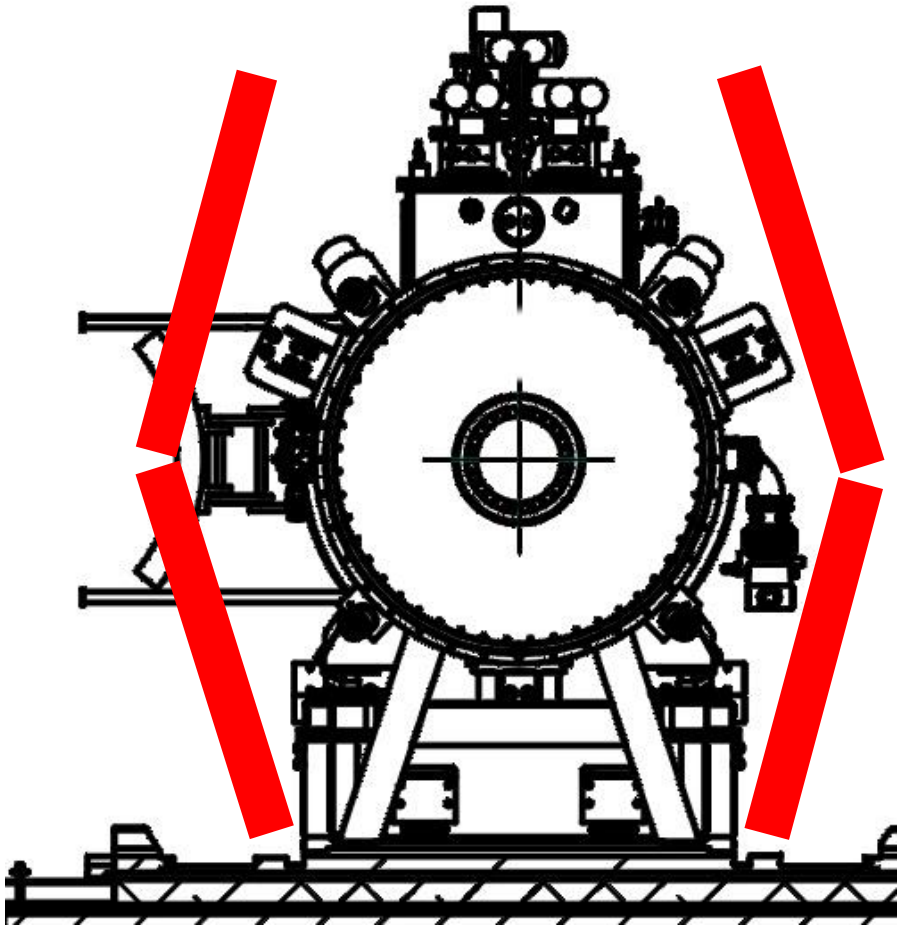
Overview

- Introduction and Concept
- CAM concept (Forces on PRY)
- Status of Manufacturing
- Effect of PRY on MICE Beam
- MICE PRY V’

Partial Return Yoke

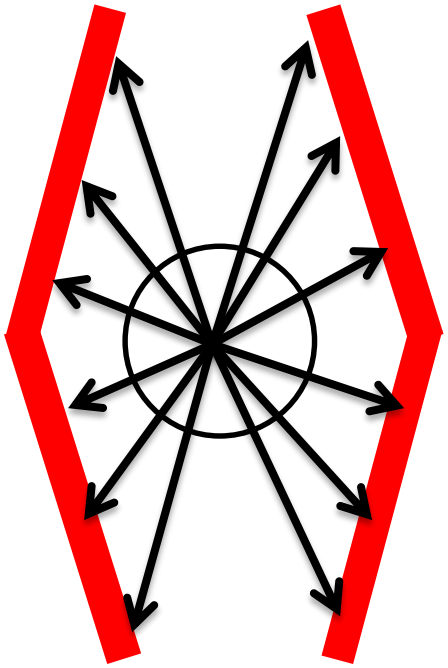
- MICE hall: solenoids cause large stray field
- Aim of PRY:
  Reduce stray field in hall to tolerable level
- Shielding plates
  - wall thickness 10 cm
  - weight: 55t
- Performance
  - Reduces stray field outside of shield to 5-10 Gauss



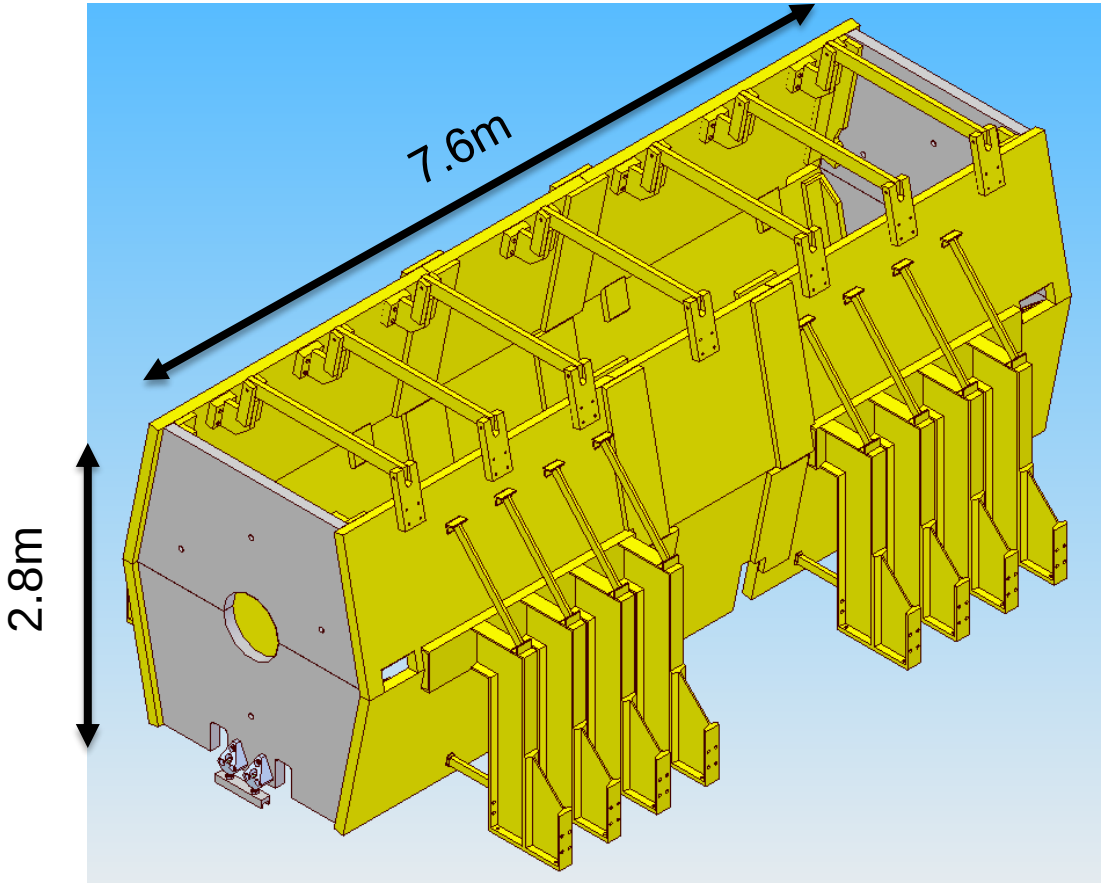
(Note: not to scale)

H Witte. Step IV & VI: Local Flux Return. MICE CM 34, October 2012.

Principle



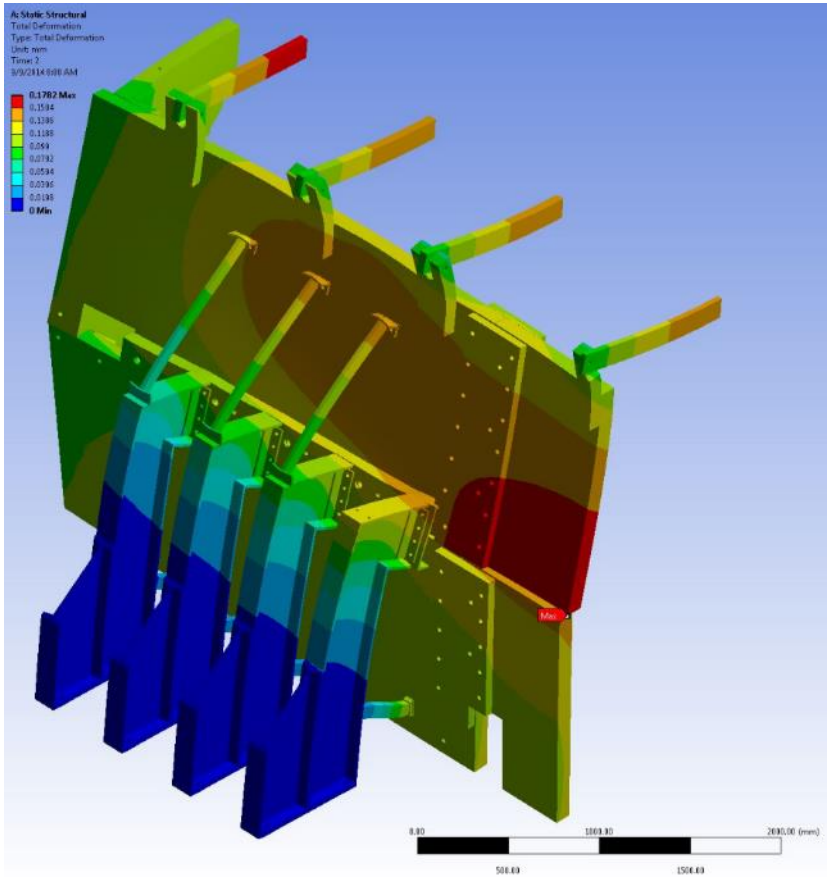
PRY Step IV



Courtesy of J. Tarrant / S. Plate

Force Scenarios

- Nominal cases
  - 200/240 MeV flip/solenoid mode
  - Deflection 0.18 mm
- Worst case analysis
  - Increased forces by factor 5
  - **Still very safe**

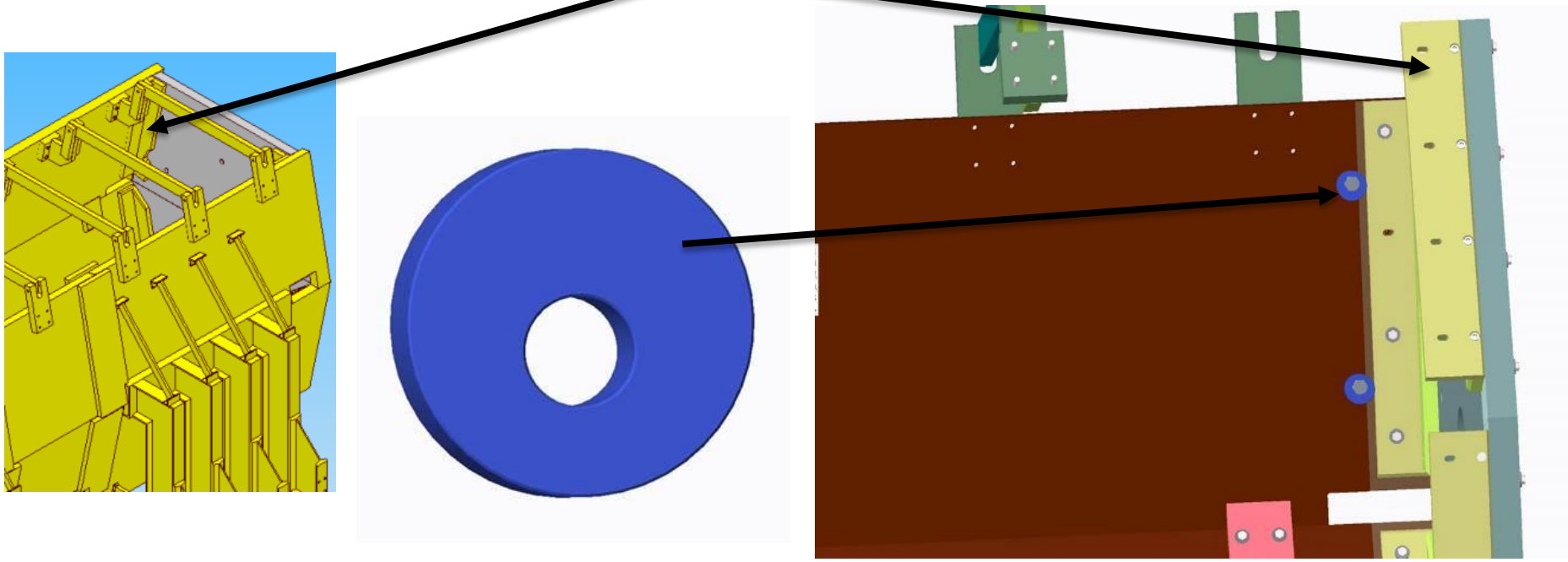


Force Scenarios

- Nominal cases
  - 200/240 MeV flip/solenoid mode
  - Deflection 0.18 mm
- Worst case analysis
  - Increased forces by factor 5
  - **Still very safe**
- Monitoring: draw-wire sensor

WDS-3000-P115-CA-P

CAM Concept



Mitigates overstressing of L-Seal bolts

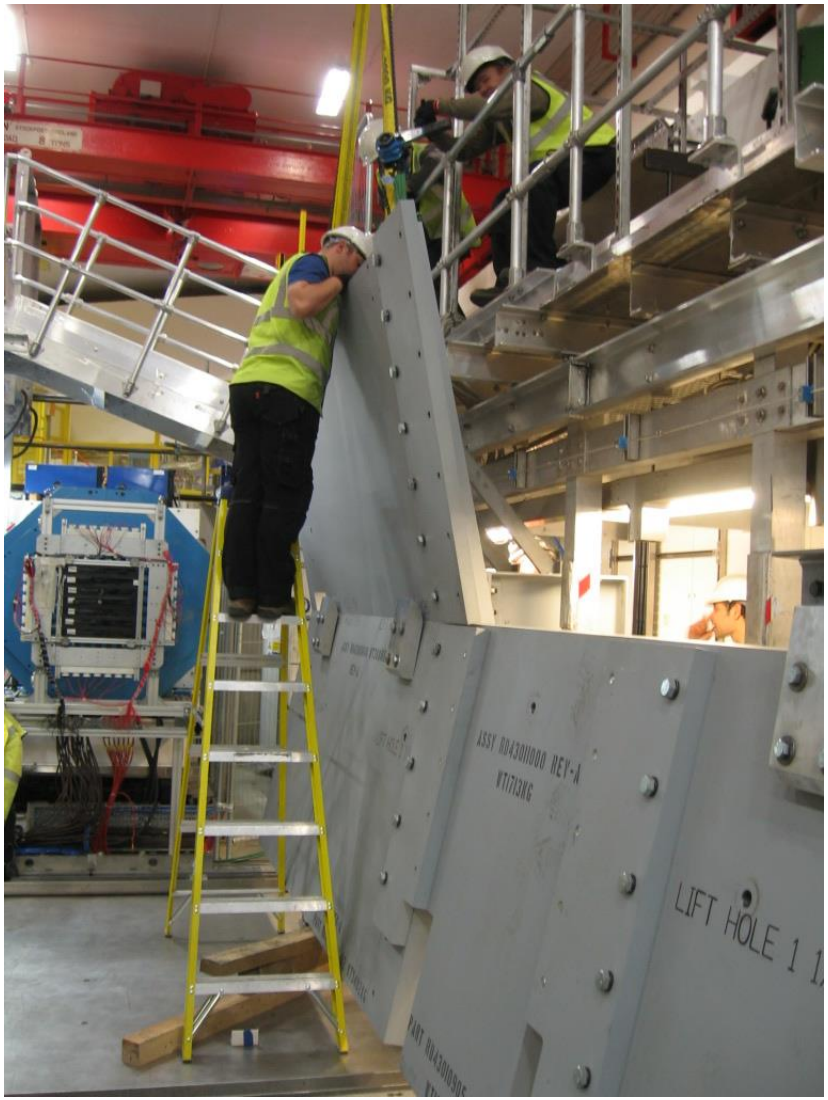
Stress analysis now ok up to 5 times calculated load on end plate of PRY

Status of Manufacturing

Schedule

- April 1st: PRY South Side complete
- April 30th: PRY North Side arrived at Liverpool port
- May 12th: PRY North Side at RAL
- May 15th: PRY North legs installed and aligned
- May 20th: Installation of north side plates

PRY South Side



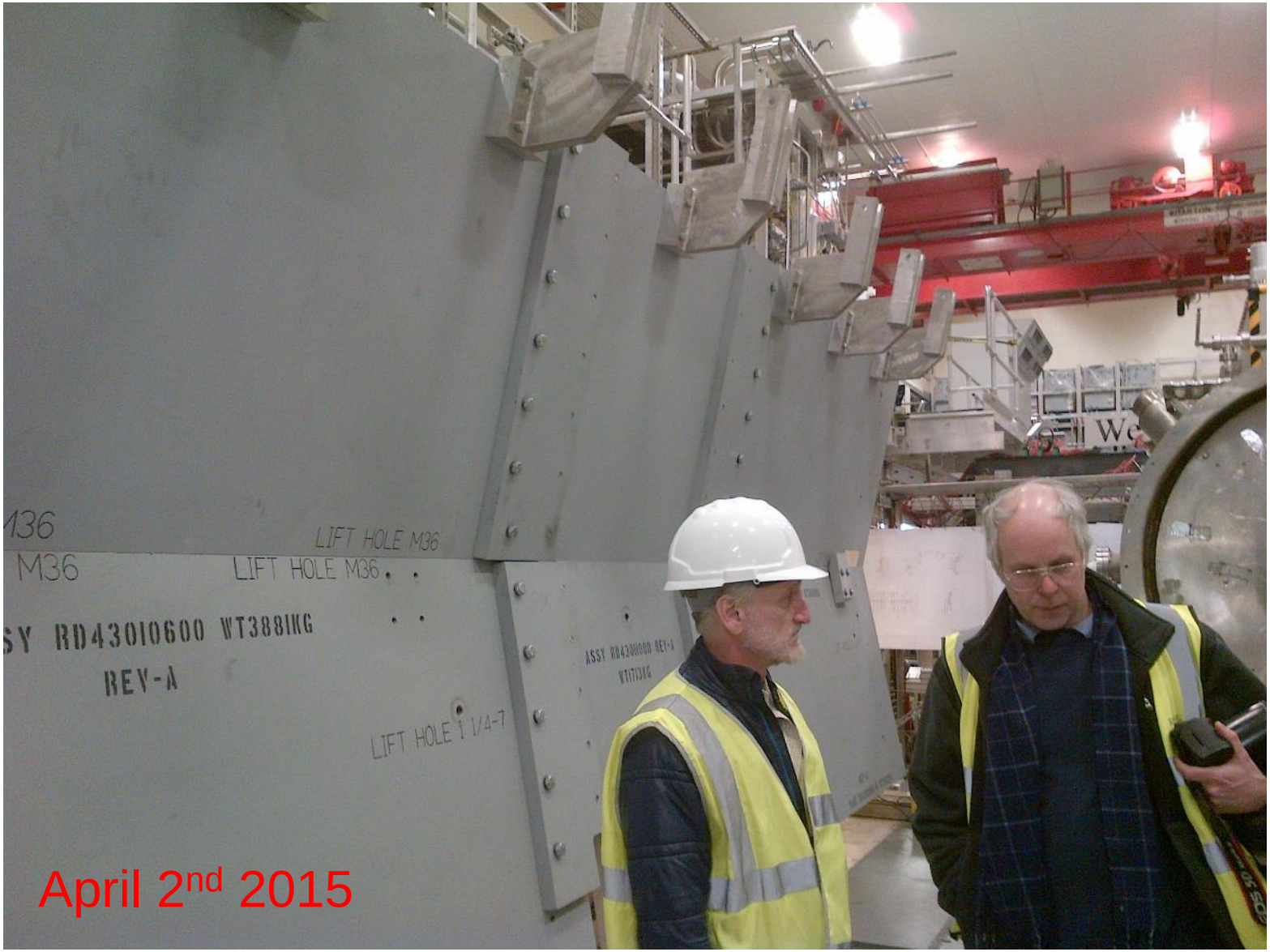
April 1st 2015

PRY South Side

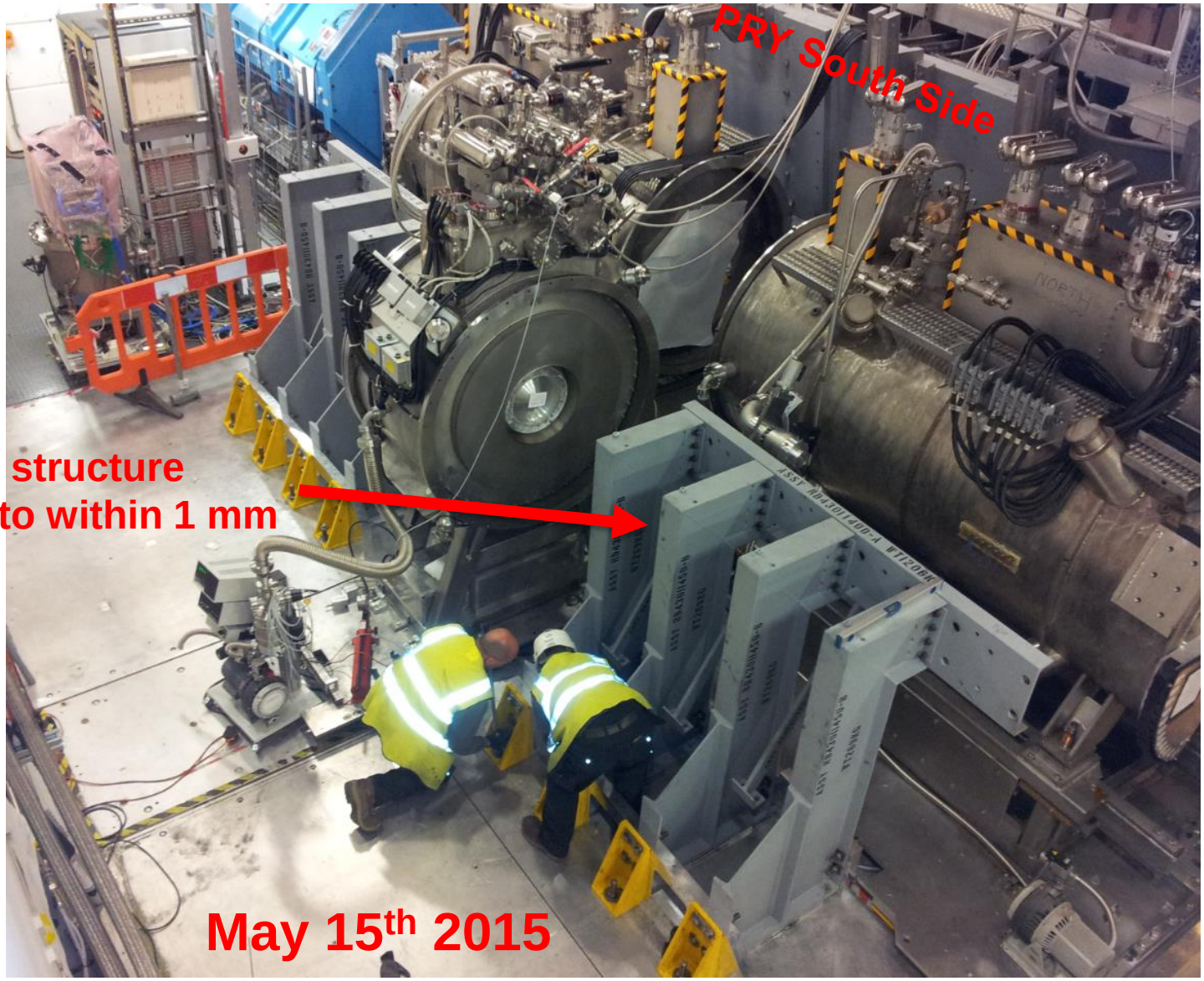
April 1st 2015

PRY South Side

PRY South Side



PRY North Side

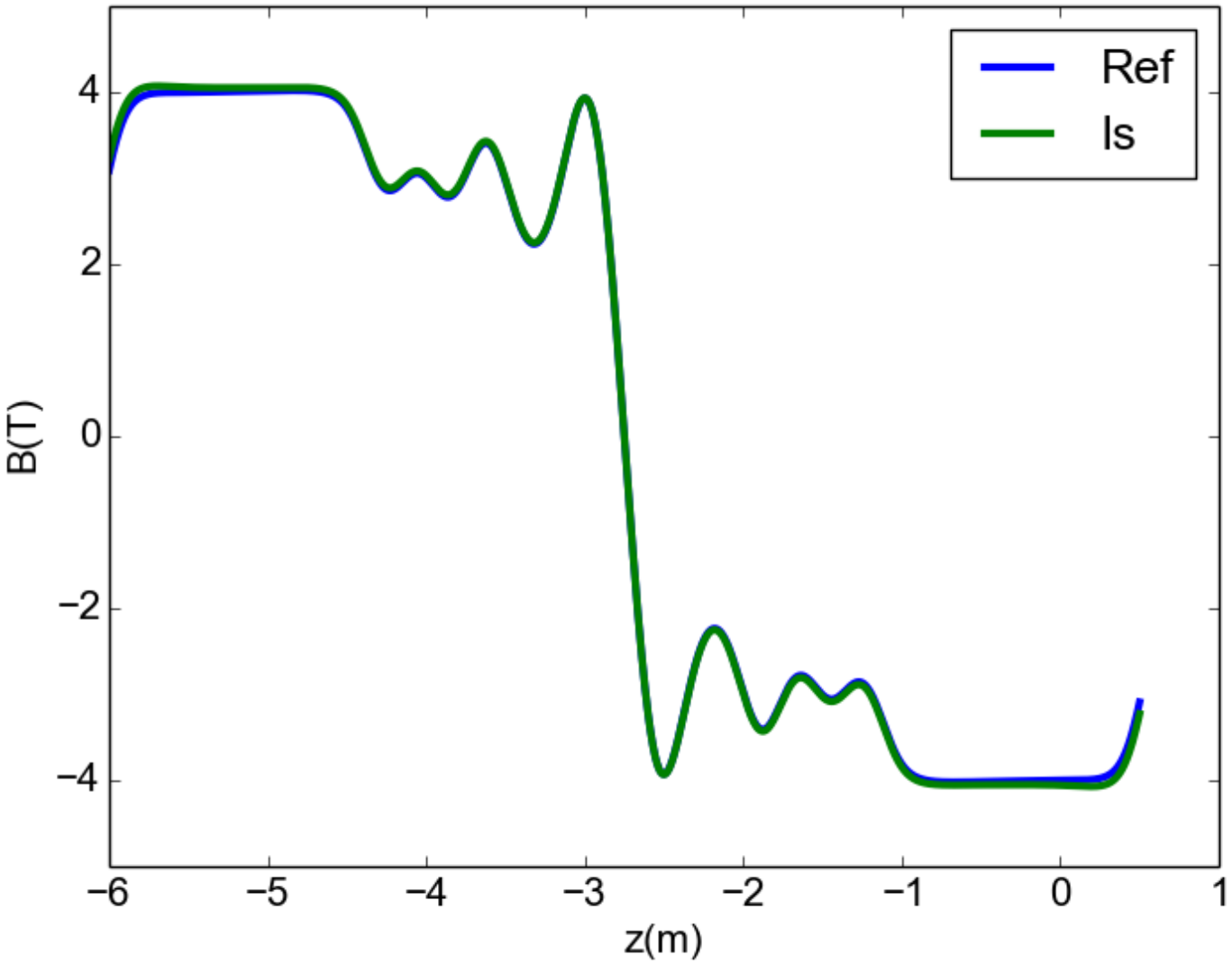


Effect of PRY on MICE Beam

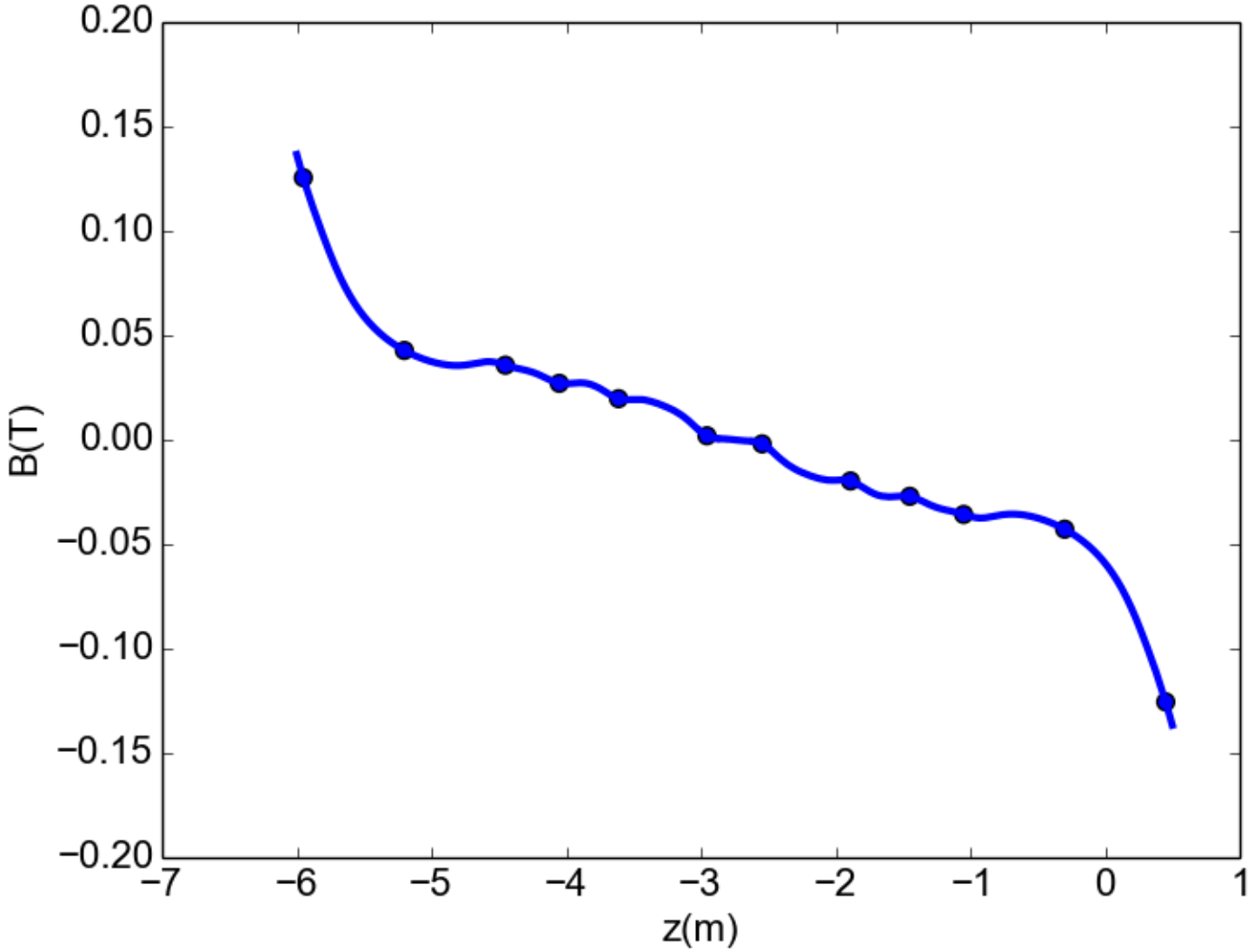
Correction MICE Coil Currents

- Solenoids run more efficiently with iron yoke
  - i.e. at nominal current longitudinal field is too large
  - Small effect (≈ %)
  - Can be corrected by tweaking coil currents, but this is a lengthy process if done manually
- New approach: perturbation theory
  - Magnetization in PRY does not change
  - Treat error field as perturbation
  - Find set of coil currents which corrects these errors

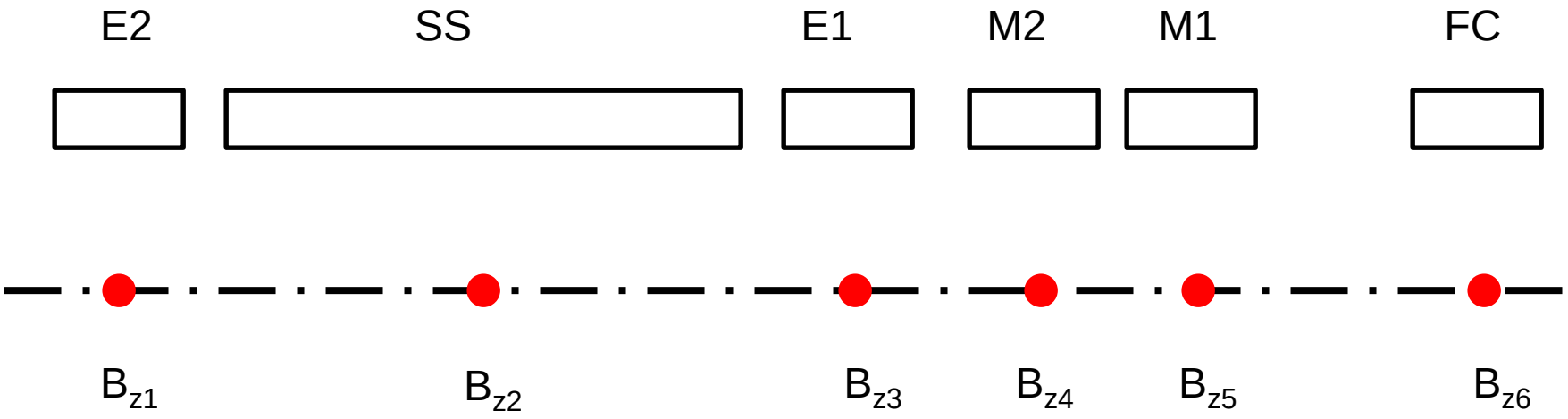
240 MeV Flip



240 MeV Flip – Field Error



Methodology

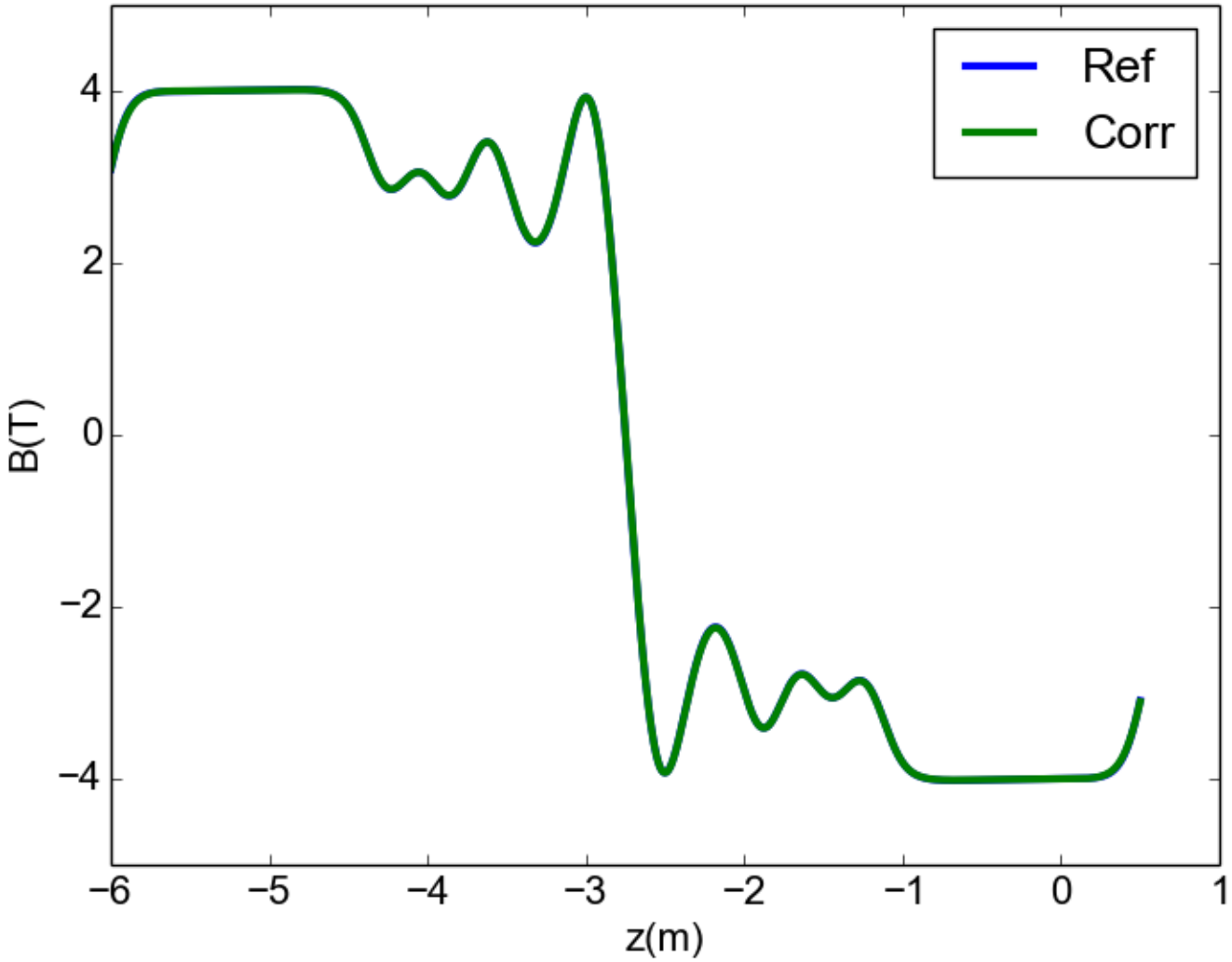


$$\begin{pmatrix} A_{11} & A_{12} & \cdots & A_{1n} \\ A_{21} & A_{22} & \cdots & A_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ A_{n1} & A_{n2} & \cdots & A_{nn} \end{pmatrix} \cdot \begin{pmatrix} I_1 \\ I_2 \\ \vdots \\ I_n \end{pmatrix} = \begin{pmatrix} B_{z1} \\ B_{z2} \\ \vdots \\ B_{zn} \end{pmatrix}$$

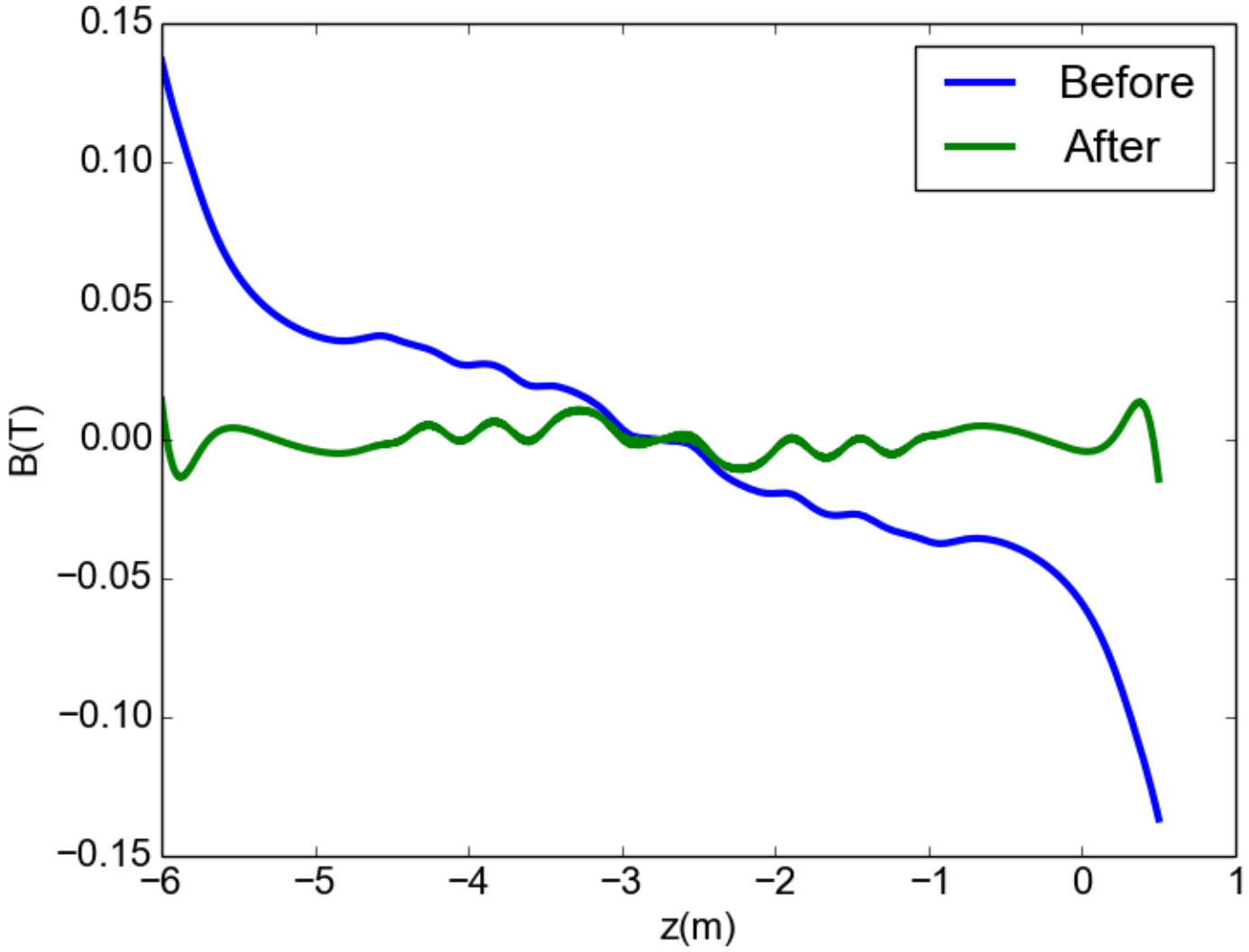
A · x = b

Linear equation system
Solve for x (=I)

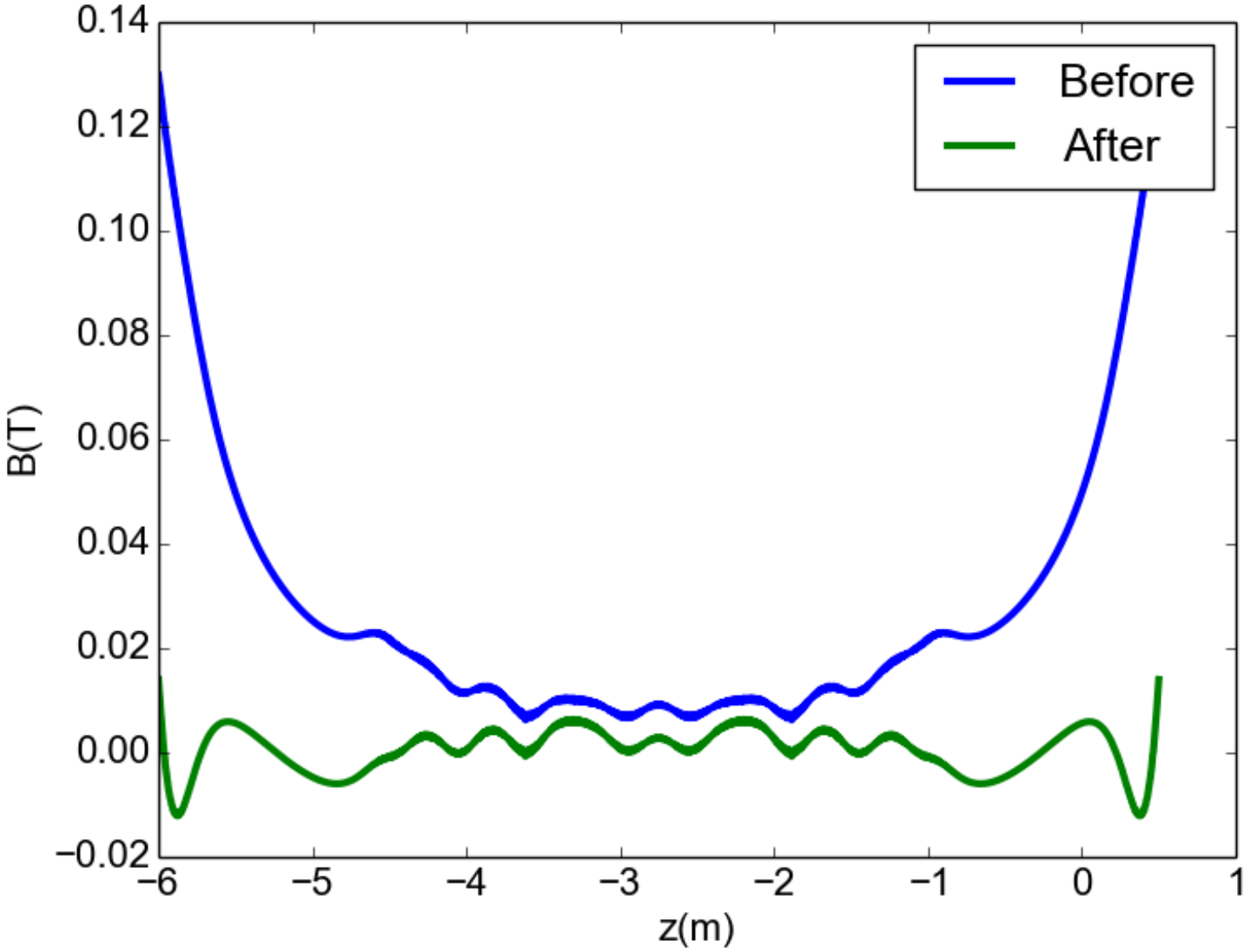
240 MeV Flip - Corrected



240 MeV Flip – Error Field

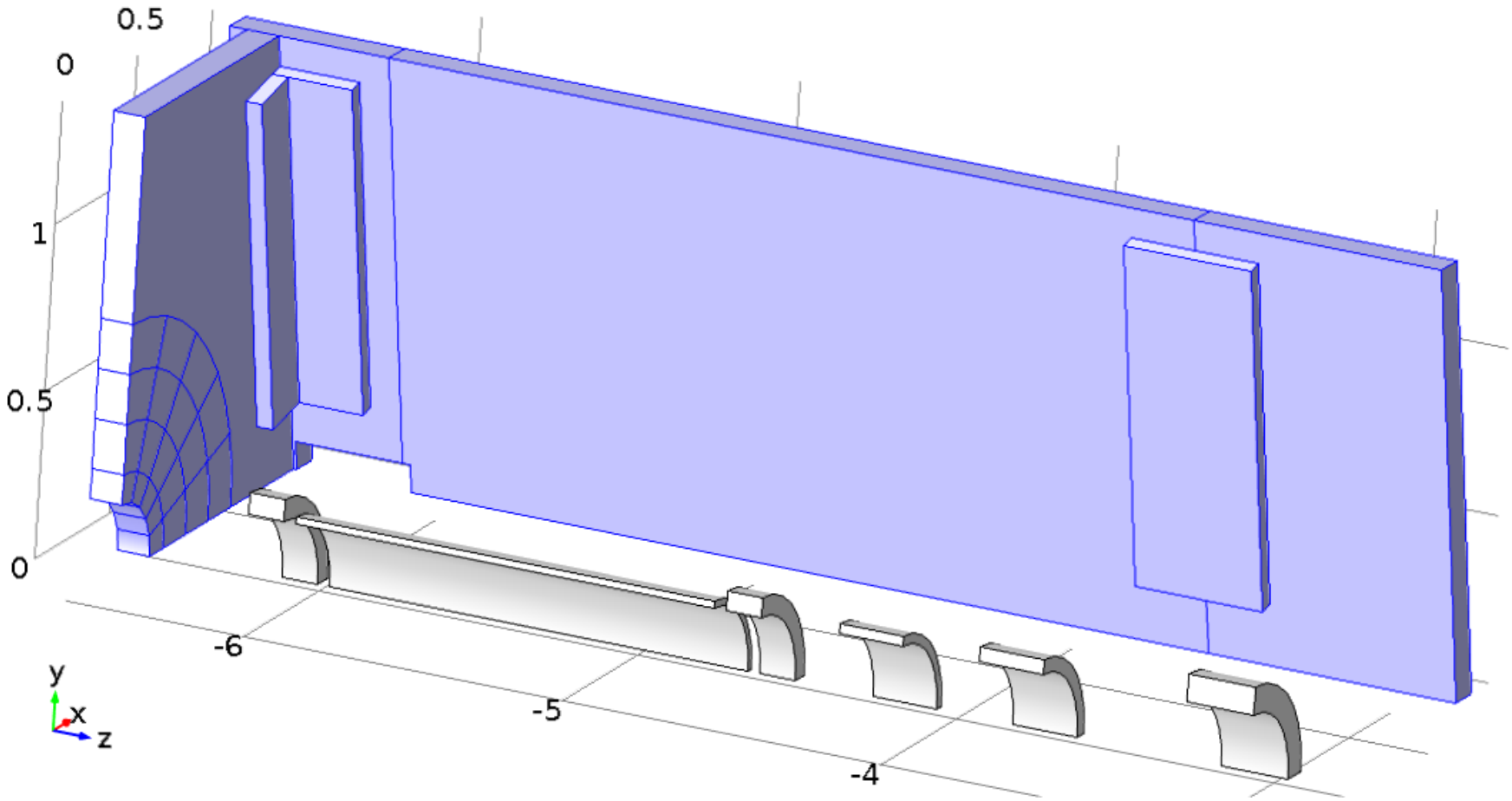


240 MeV Sol – Error Field



Uncorrectable Error

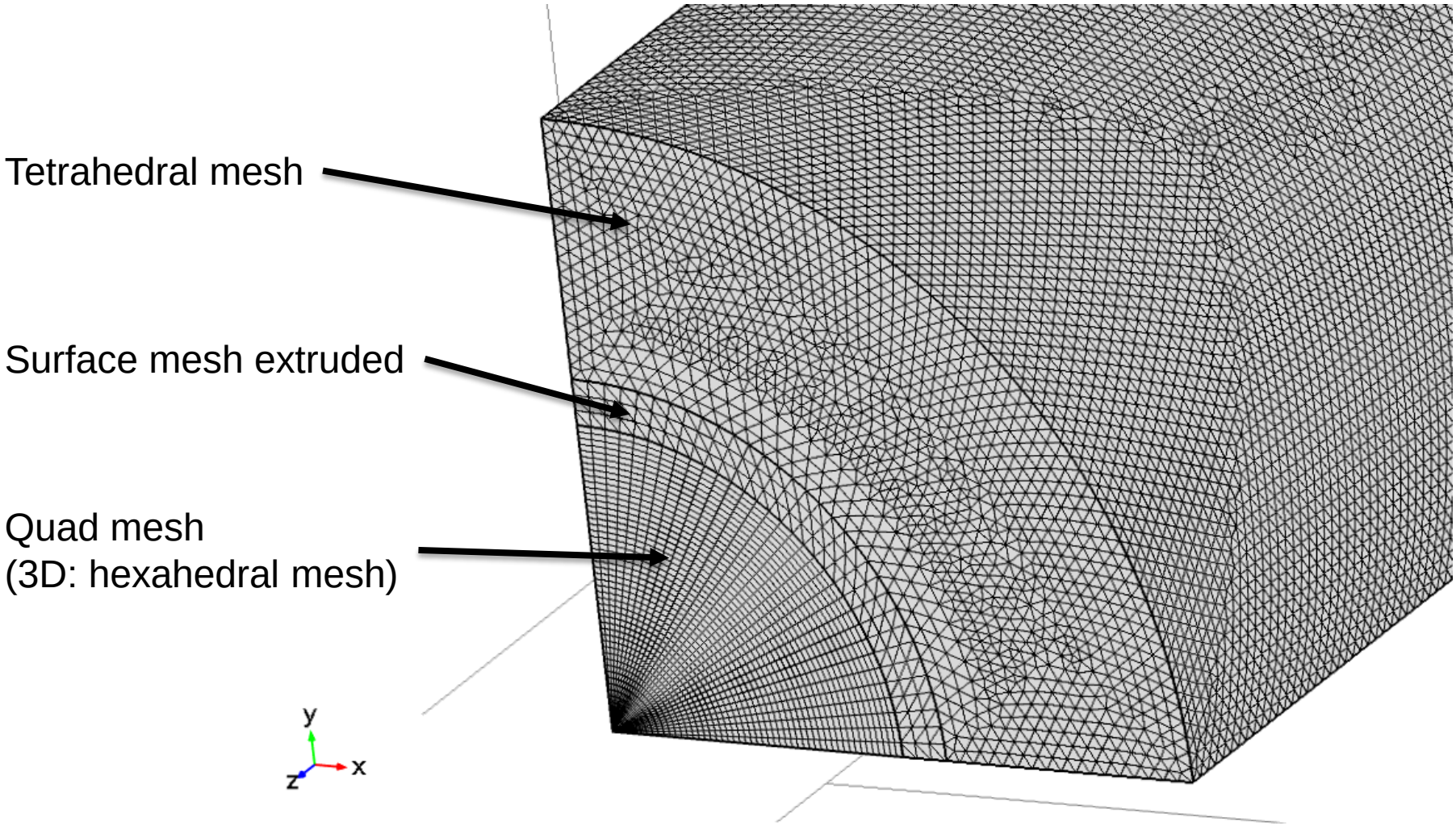
Partial iron return yoke: causes asymmetry of field



Evaluate by looking at field harmonics

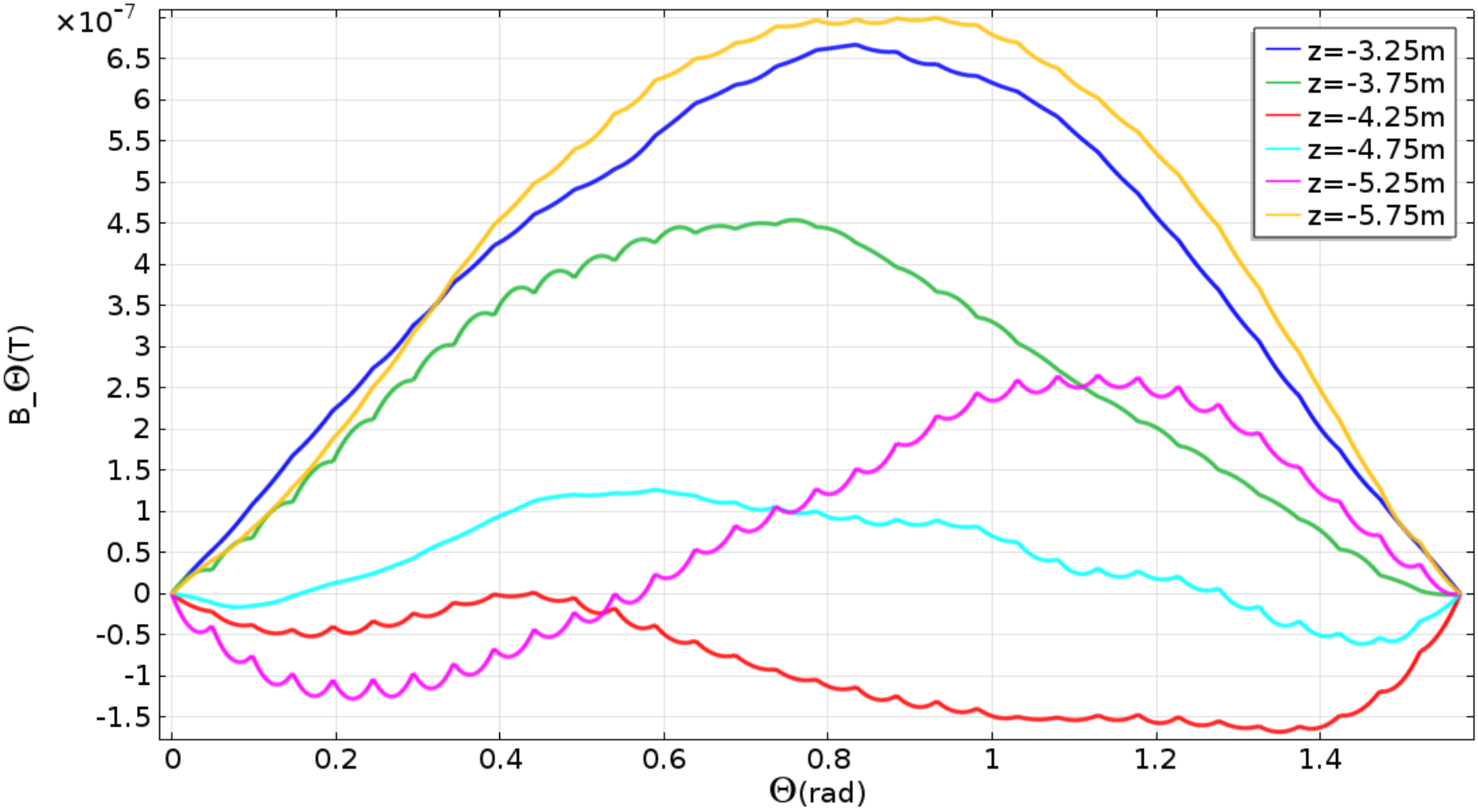
Central Mesh

Small effect, good accuracy required – need very fine mesh

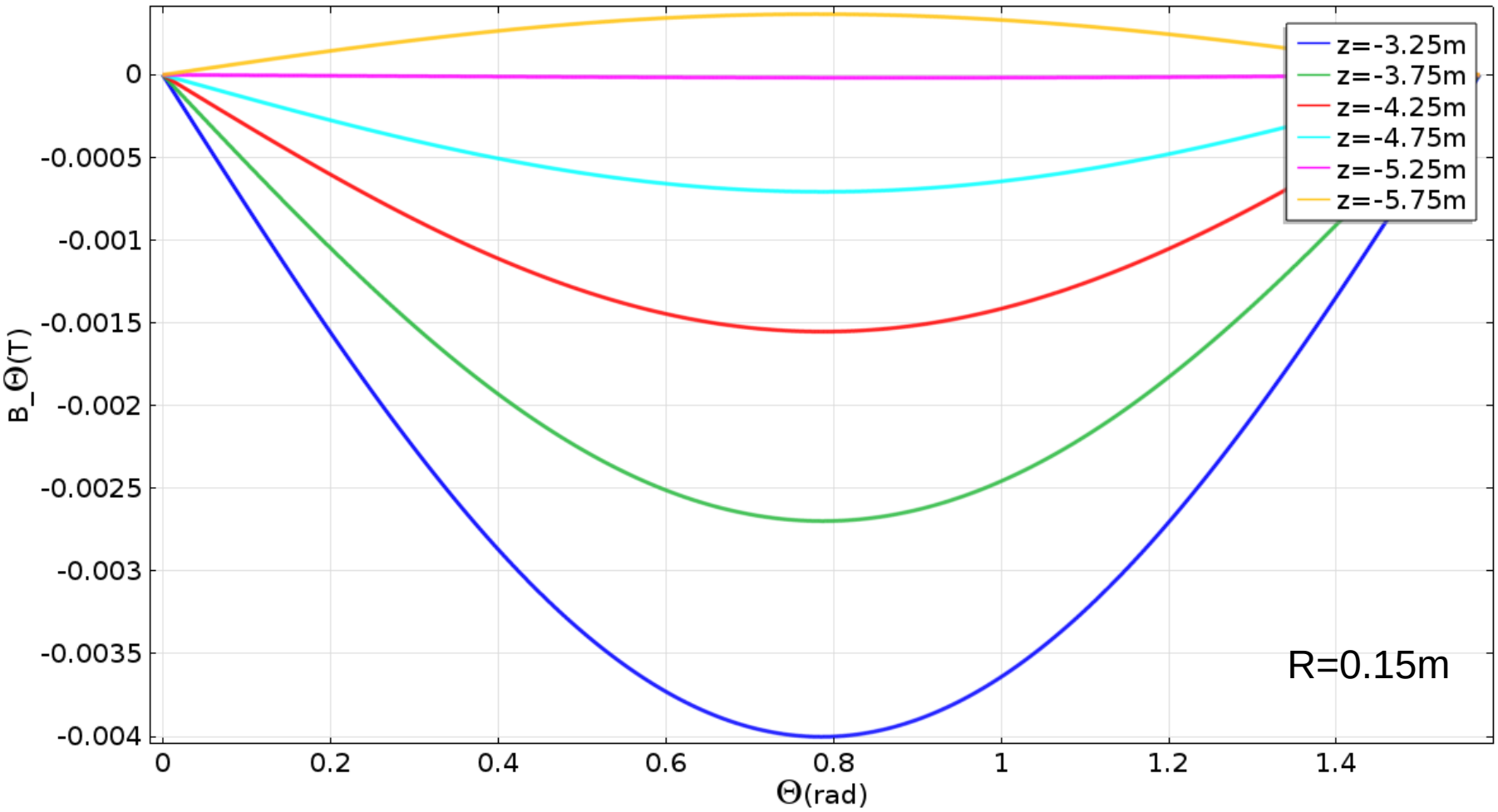


Azimuthal Field – No Iron

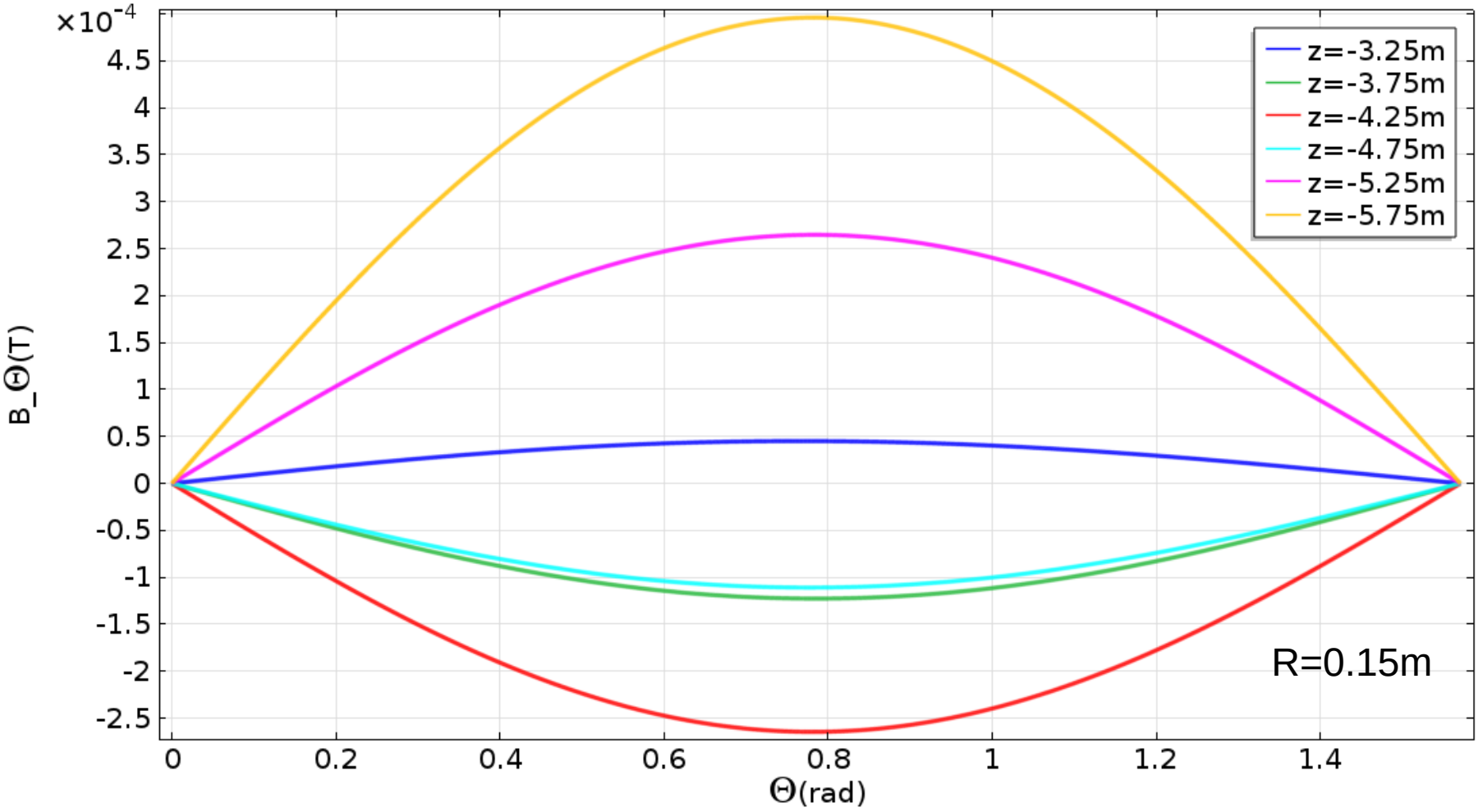
Mesh good enough? Test with case we know the answer for!



Step IV, 240 MeV Flip



Step IV, 240 MeV Solenoid



Harmonics 240 MeV Flip

	A	B
1	-5.00E-20	-1.30E-19
2	1.77E-06	4.00E-03
3	5.11E-20	5.98E-19
4	6.23E-19	-1.78E-18
5	-3.85E-20	4.32E-19
6	-1.29E-06	-2.85E-07
7	1.01E-19	3.96E-19
8	-5.34E-19	6.30E-19
9	-5.11E-20	5.26E-19
10	-4.77E-07	2.44E-09
11	-1.26E-20	-1.66E-19

Z=-3.25m

	A	B
1	1.00E-19	-2.19E-19
2	4.25E-06	2.70E-03
3	-1.19E-19	4.43E-19
4	5.86E-19	-8.93E-19
5	2.92E-19	4.02E-19
6	-3.10E-06	-1.80E-07
7	-3.64E-19	7.93E-20
8	-3.18E-19	2.02E-19
9	2.64E-19	2.98E-19
10	-1.14E-06	5.95E-09
11	-1.73E-19	-4.09E-20

Z=-3.75m

	A	B
1	7.48E-20	-1.01E-19
2	2.51E-06	1.55E-03
3	-9.58E-20	2.40E-19
4	3.07E-19	-6.09E-19
5	2.02E-19	2.10E-19
6	-1.84E-06	-4.50E-08
7	-1.71E-19	3.06E-20
8	-3.08E-19	1.74E-19
9	9.58E-20	1.31E-19
10	-6.76E-07	9.77E-09
11	-1.06E-19	-2.95E-20

Z=-4.25m

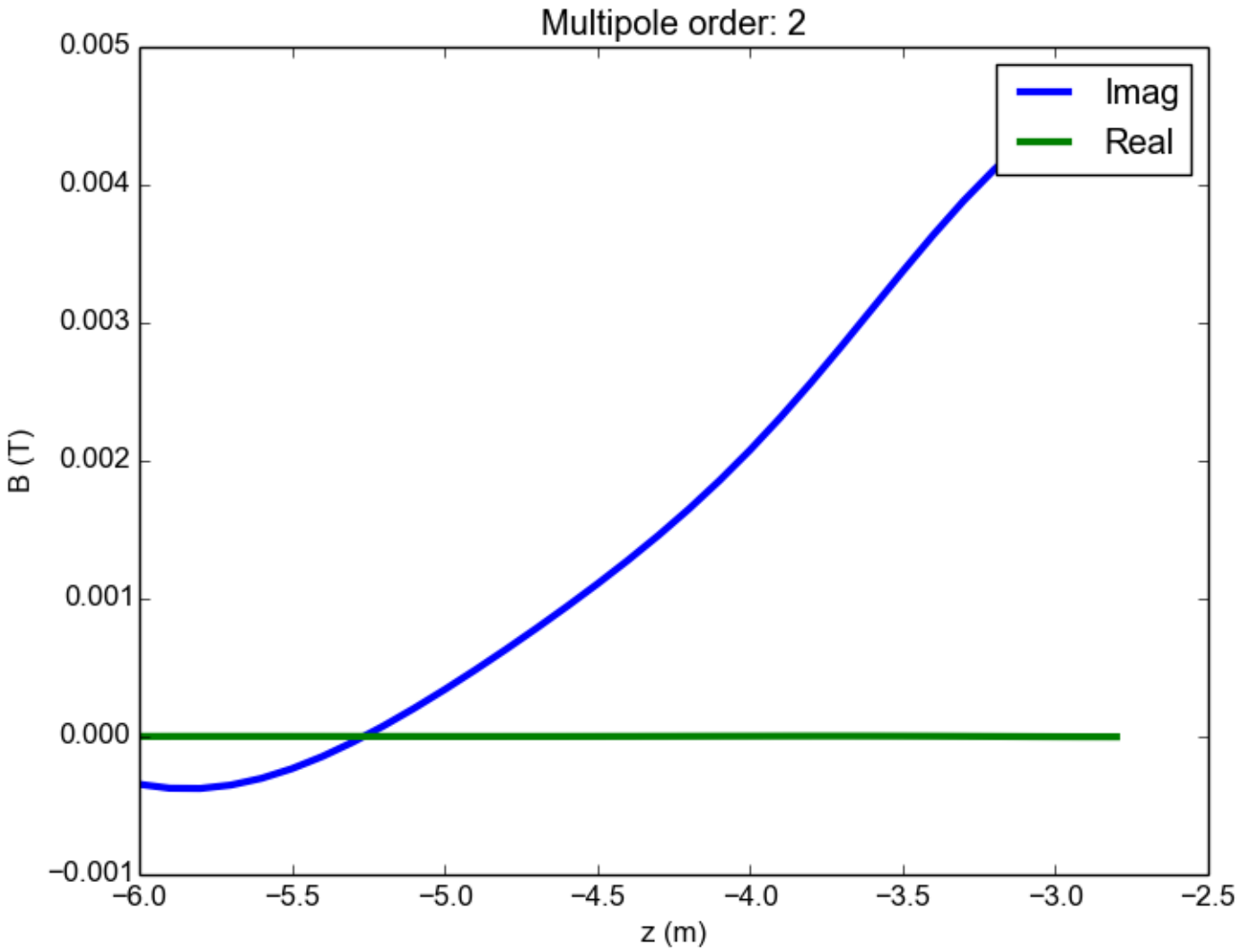
	A	B
1	6.65E-20	-9.05E-20
2	1.25E-06	7.07E-04
3	-5.38E-20	1.17E-19
4	1.45E-19	-3.08E-19
5	6.43E-20	1.40E-19
6	-9.15E-07	-8.40E-09
7	-1.02E-19	-2.82E-20
8	-8.09E-20	9.49E-20
9	3.57E-20	6.23E-20
10	-3.32E-07	7.27E-09
11	-1.05E-20	2.32E-20

Z=-4.75m

A: real harmonics
B: skew harmonics

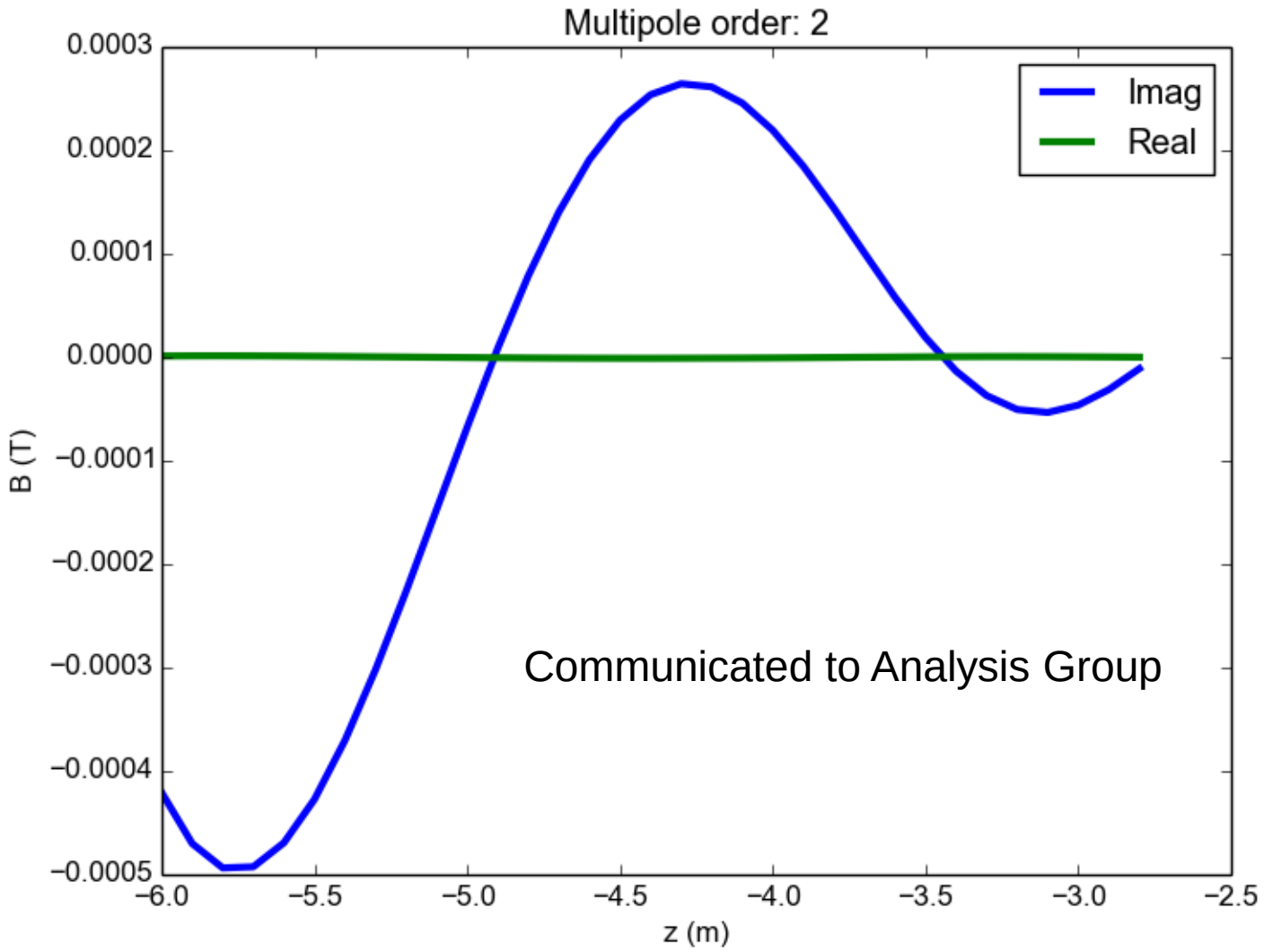
R=0.15m

Harmonics 240 MeV Flip



R=0.15m

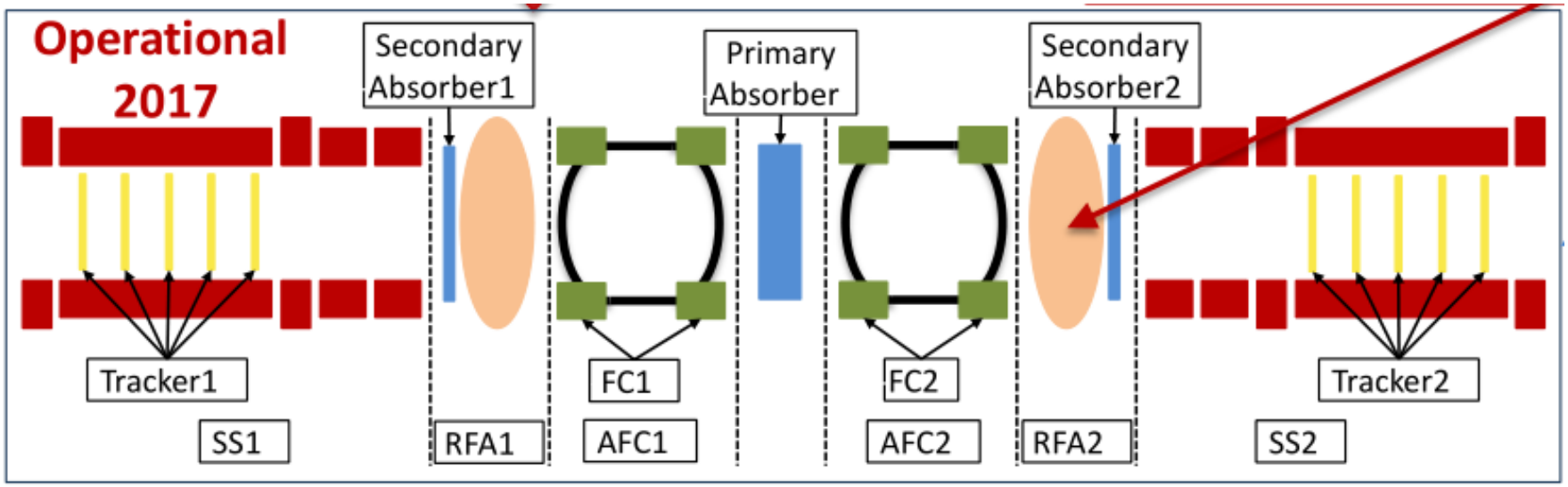
Harmonics 240 MeV Solenoid



R=0.15m

MICE Step V’

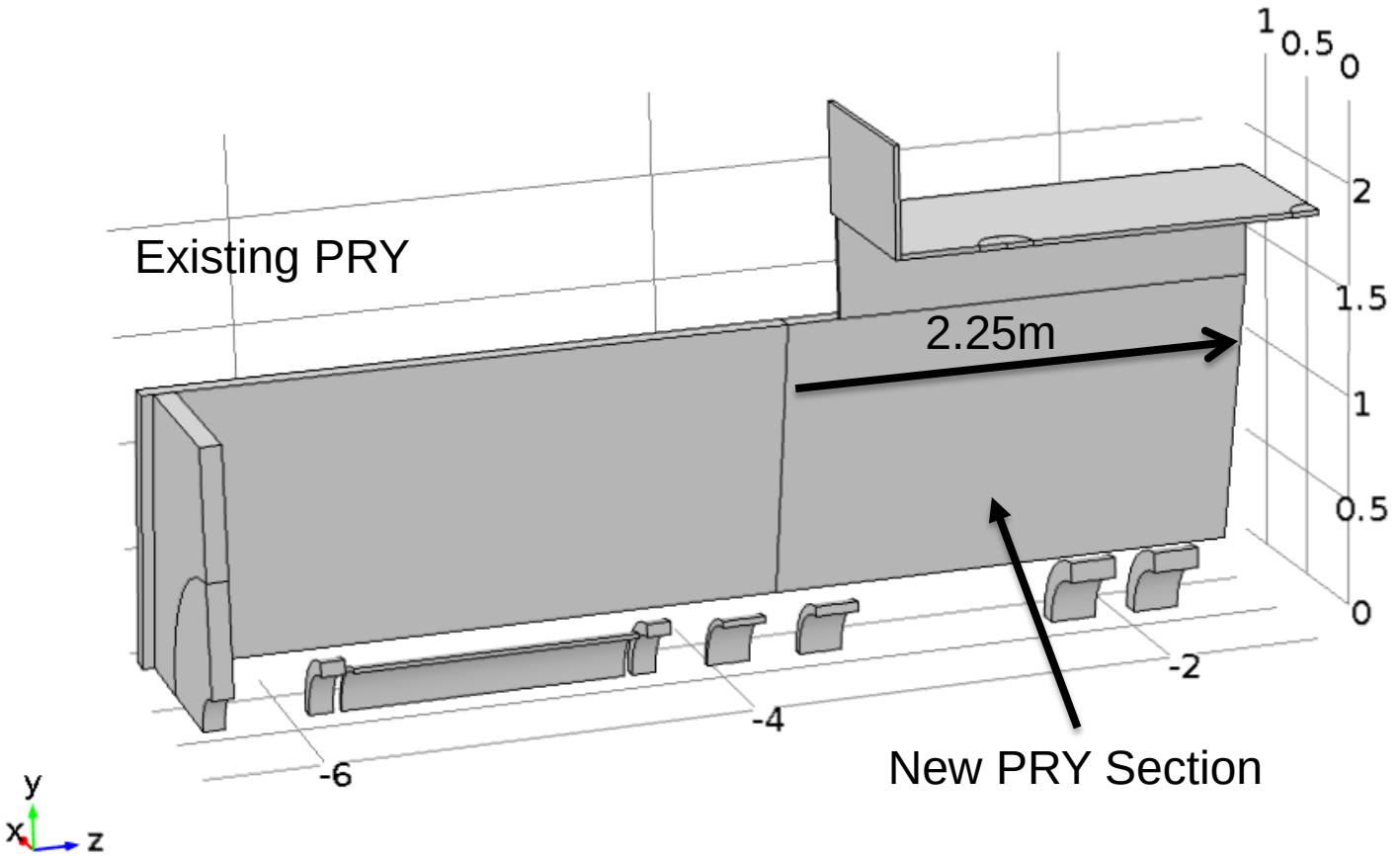
MICE Step V'



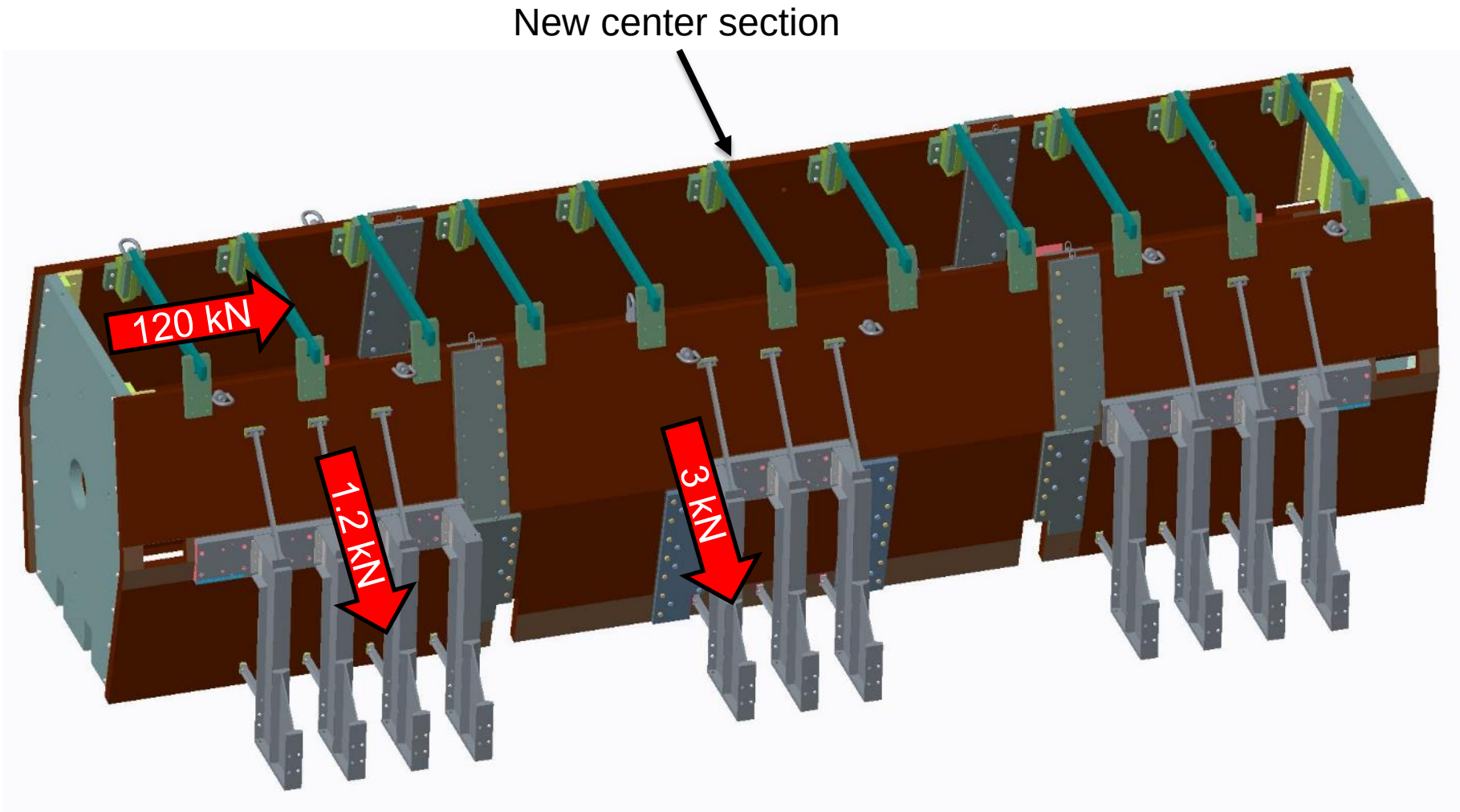
- Two versions
  - Reference design (J. Pasternak, V. Blackmore, …)
  - Alternative design (Chris Rogers)
- Described in MICE Note 450

PRY MICE Final Step

Doghouse may be required to shield vacuum pumps



Engineering



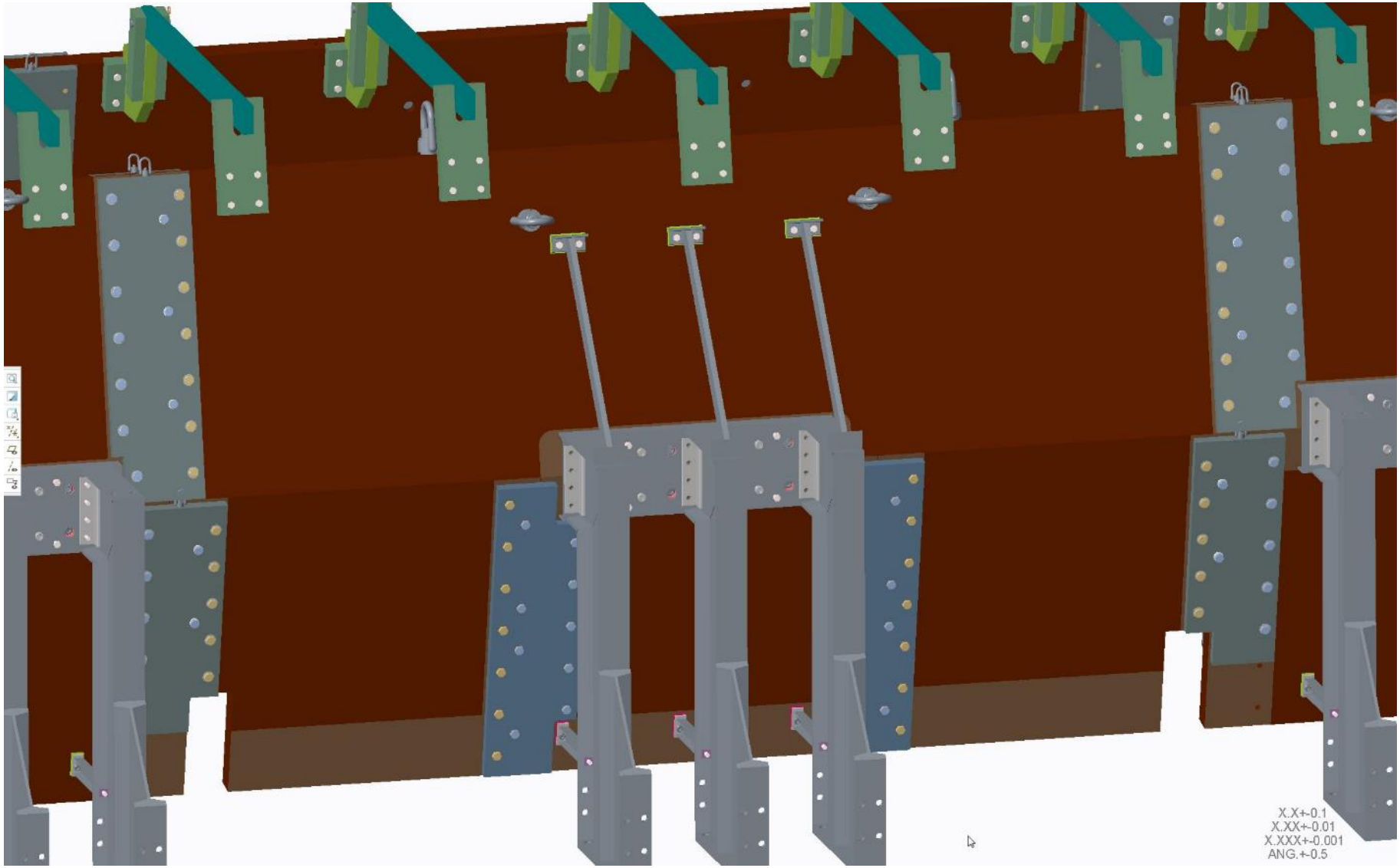
Aim: drawings complete by beginning of June

Summary

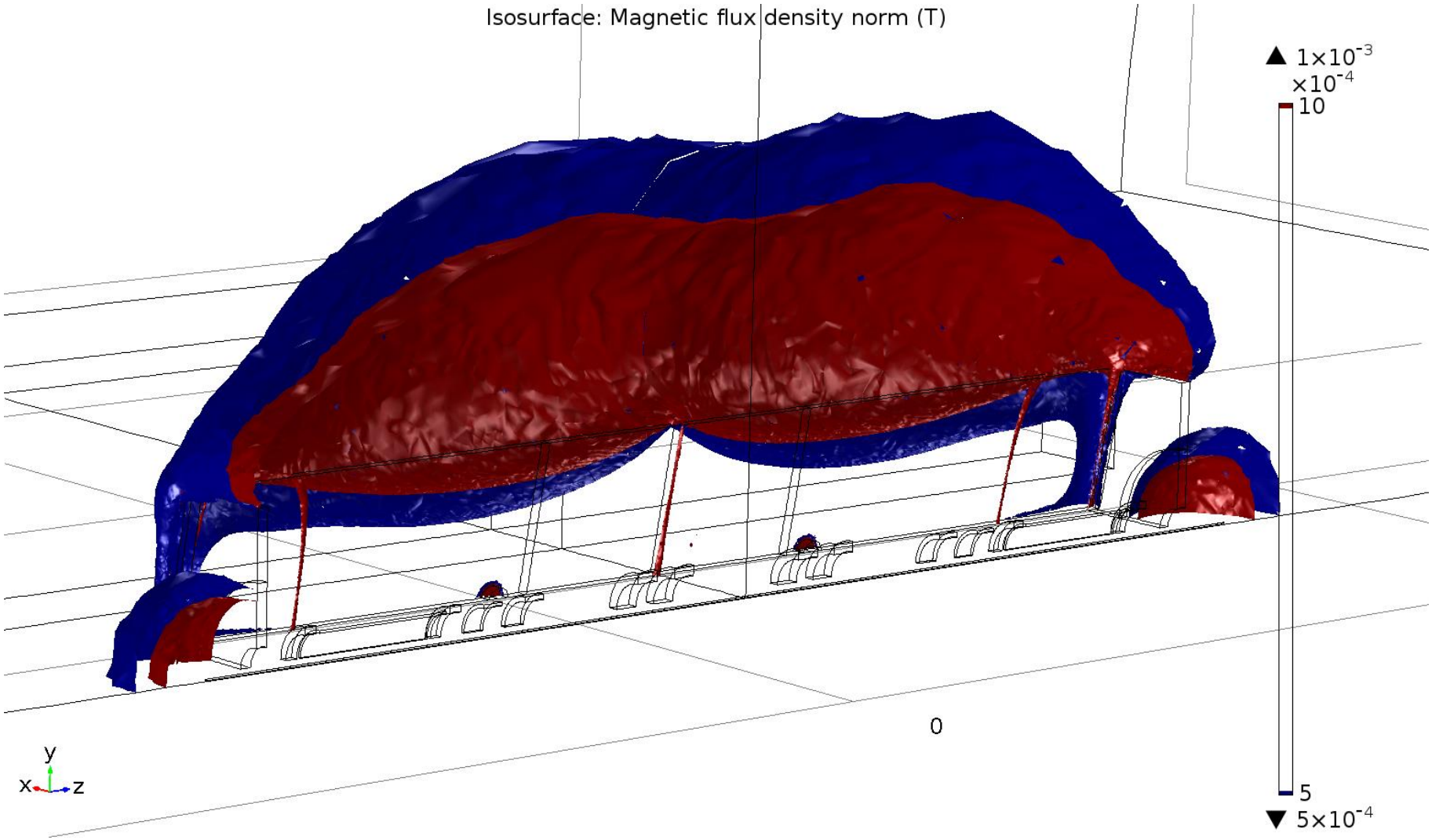
- Manufacturing PRY Step IV
  - South side complete and installed
  - North side: at RAL
  - Installation ongoing
- Effect of PRY on beam
  - Procedure for correction of solenoid currents
  - Effect of non-correctable error on beam quantified
- PRY MCE Step V’
  - Engineering ongoing, expected to be finished June 1st

Additional Slides

Engineering



Ref Lattice - 5/10 Gauss No Doghouse



Reference Lattice