Analysis MEMO

Magnetic field shield for S-2S TOF detector

9Mar2015

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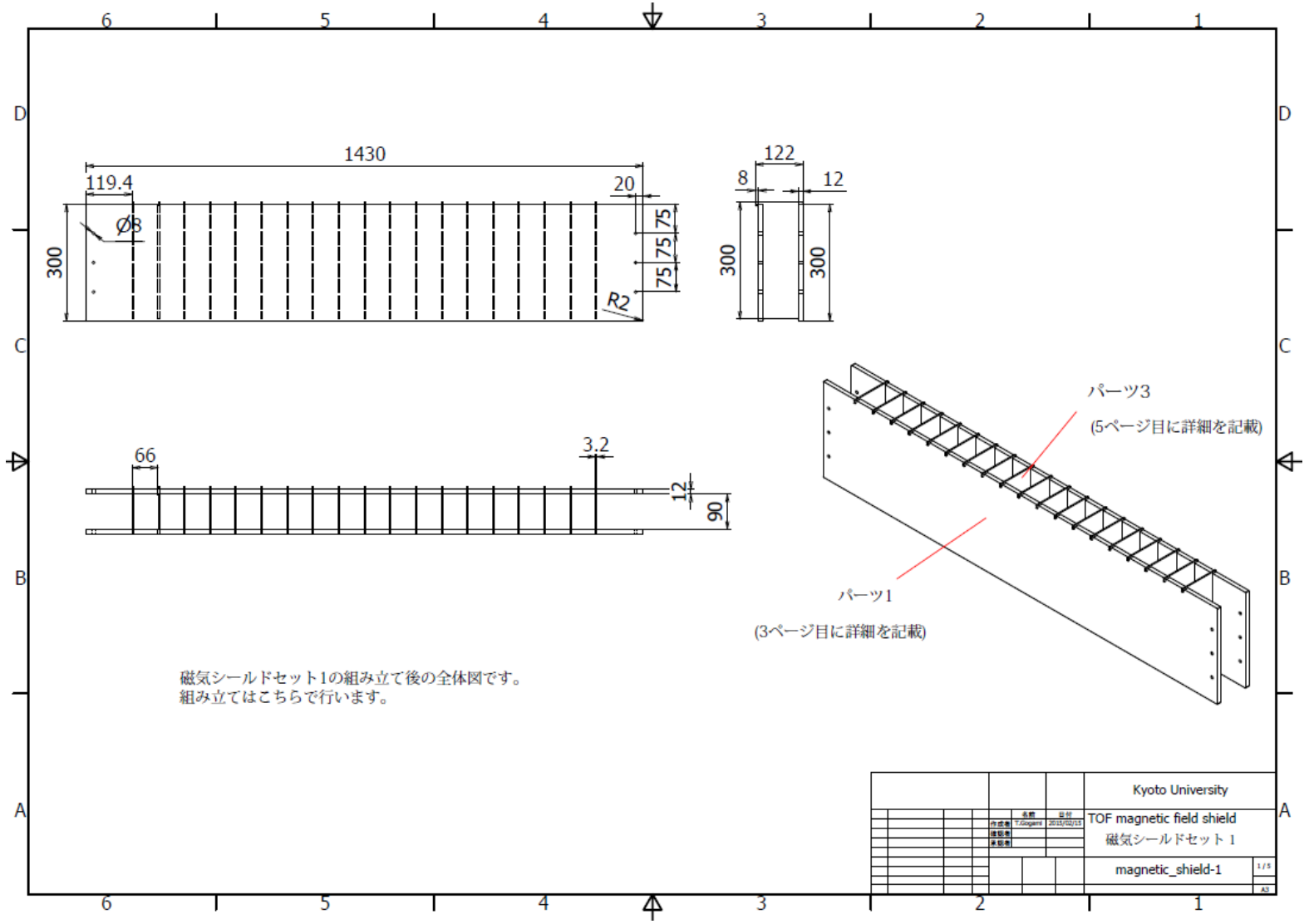
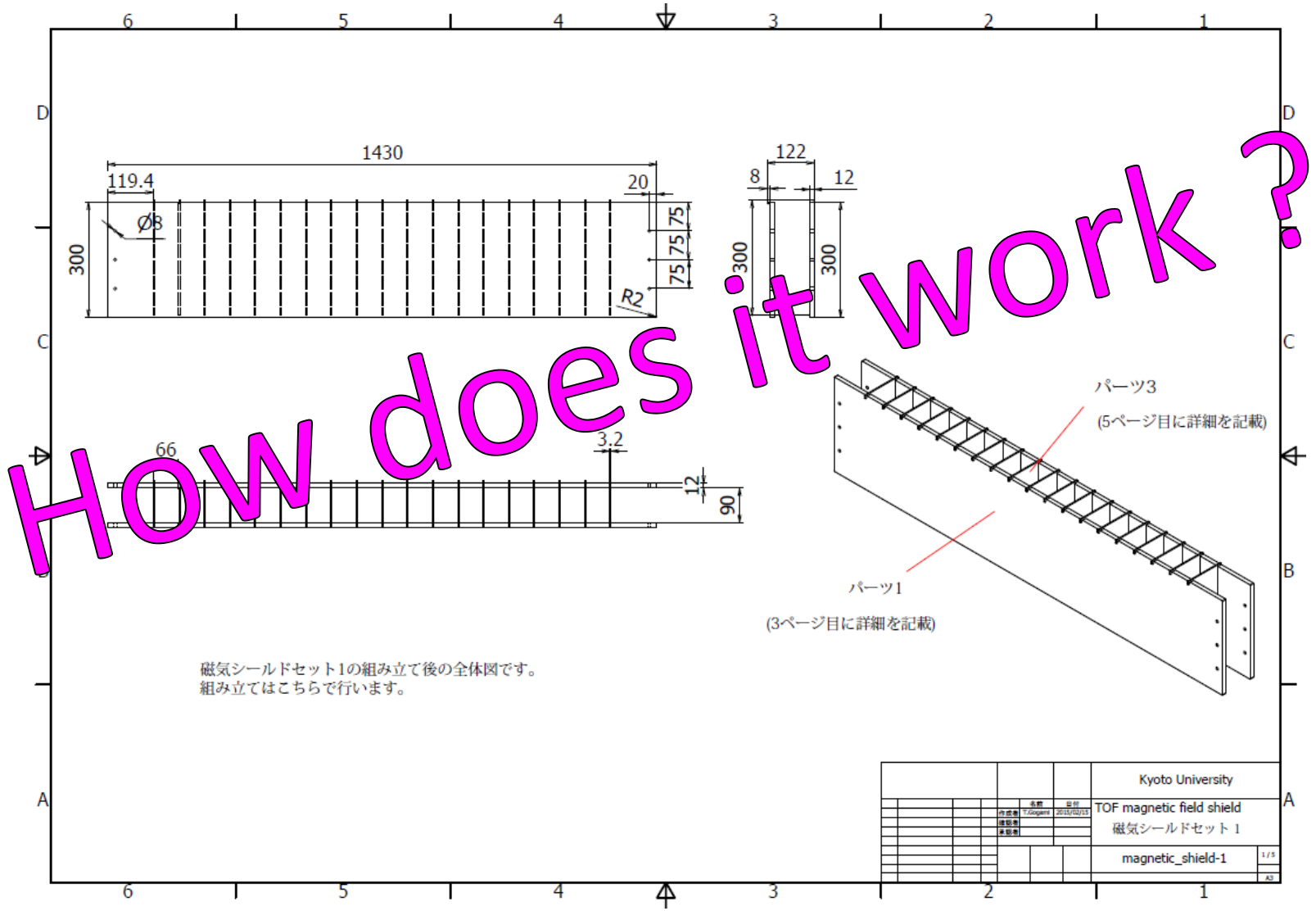
考えていたTOF用磁気シールドのシールド性能のTOSCA計算によるスタディ

Iron shield for magnetic field on PMT of TOF detector



Iron shield for magnetic field on PMT of TOF detector

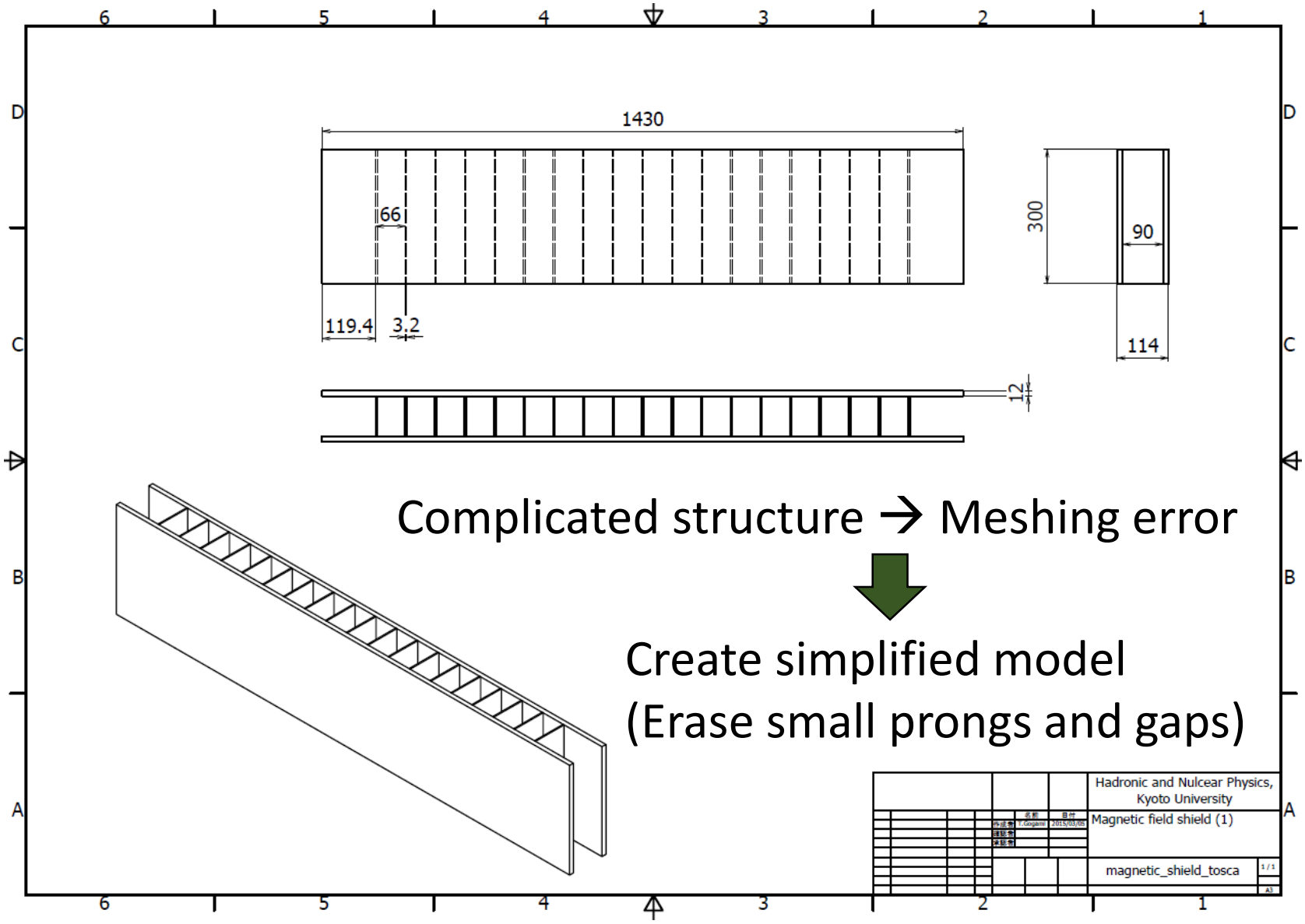


How does it work ?

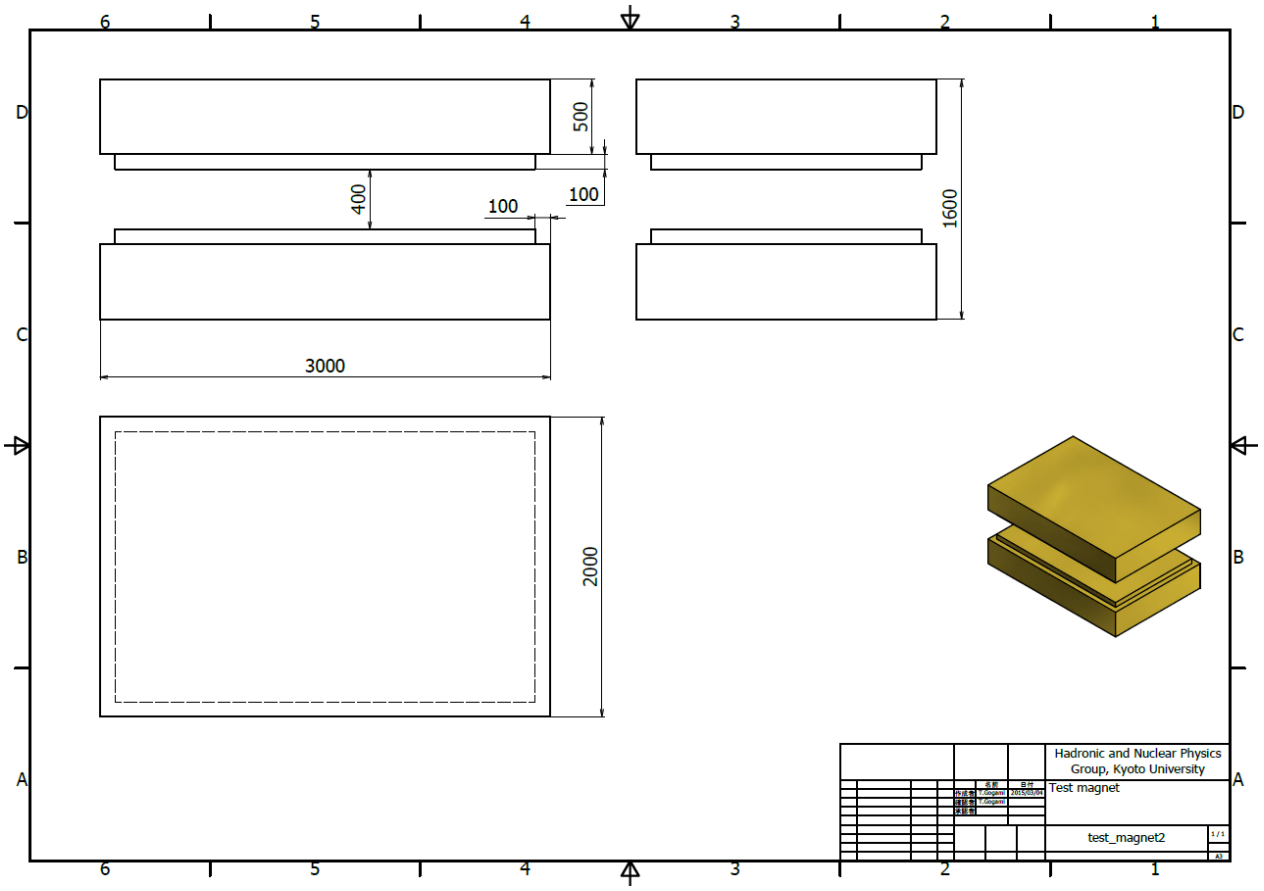
Procedure of TOSCA calculation

1. Implemented electromagnet in a model
2. Put iron shield
3. Investigated a shield effect for the magnetic field

Simplified the shield model



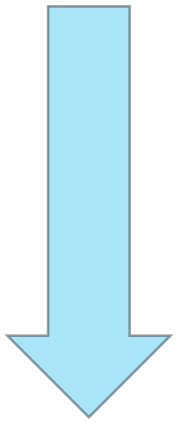
Electromagnet implementation in TOSCA model



1. Design a shape of iron with Auto CAD Inventor.
2. Converted to SAT file.
3. Imported the SAT file to modeler of Opera3D (TOSCA).
4. Implemented coils on the iron.
5. Optimized the current density.

Flow chart of the calculation (TOSCA)

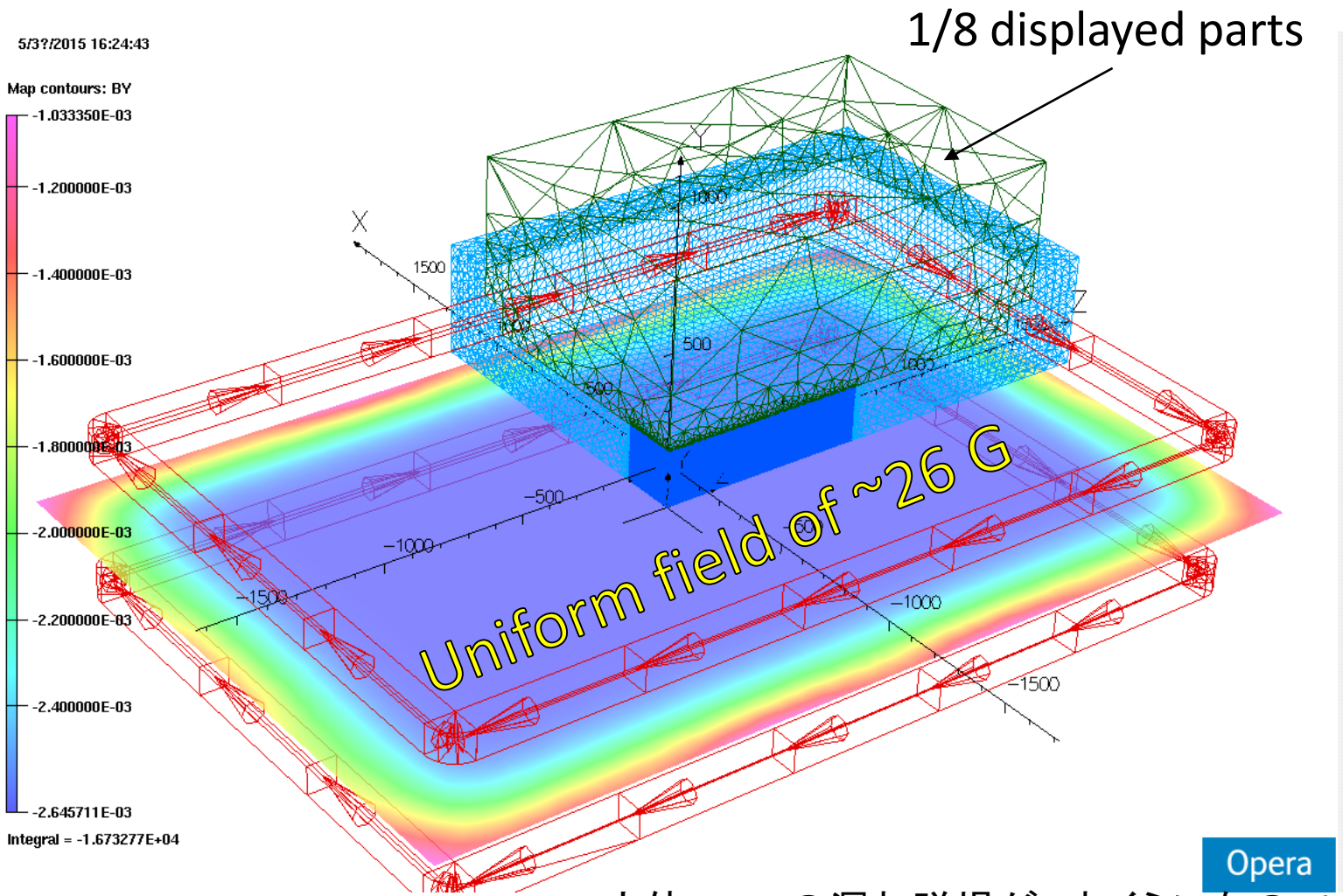
Modeler (Modeling)



Solver (Calculation)

Post processor (Showing results)

Electromagnet in TOSCA model



Magn Scalar Pot	A
Current Density	A mm^{-2}
Power	W
Force	N

MODEL DATA

test_magnet_20.op3
TOSCA Magnetostatic
Linear materials
Simulation No 1 of 1
4899324 elements
829061 nodes
3 conductors
Nodally interpolated fields
Activated in global coordinates
Reflection in XY plane (Z field=0)
Reflection in YZ plane (X field=0)
Reflection in ZX plane (Z+X fields=0)

Field Point Local Coordinates

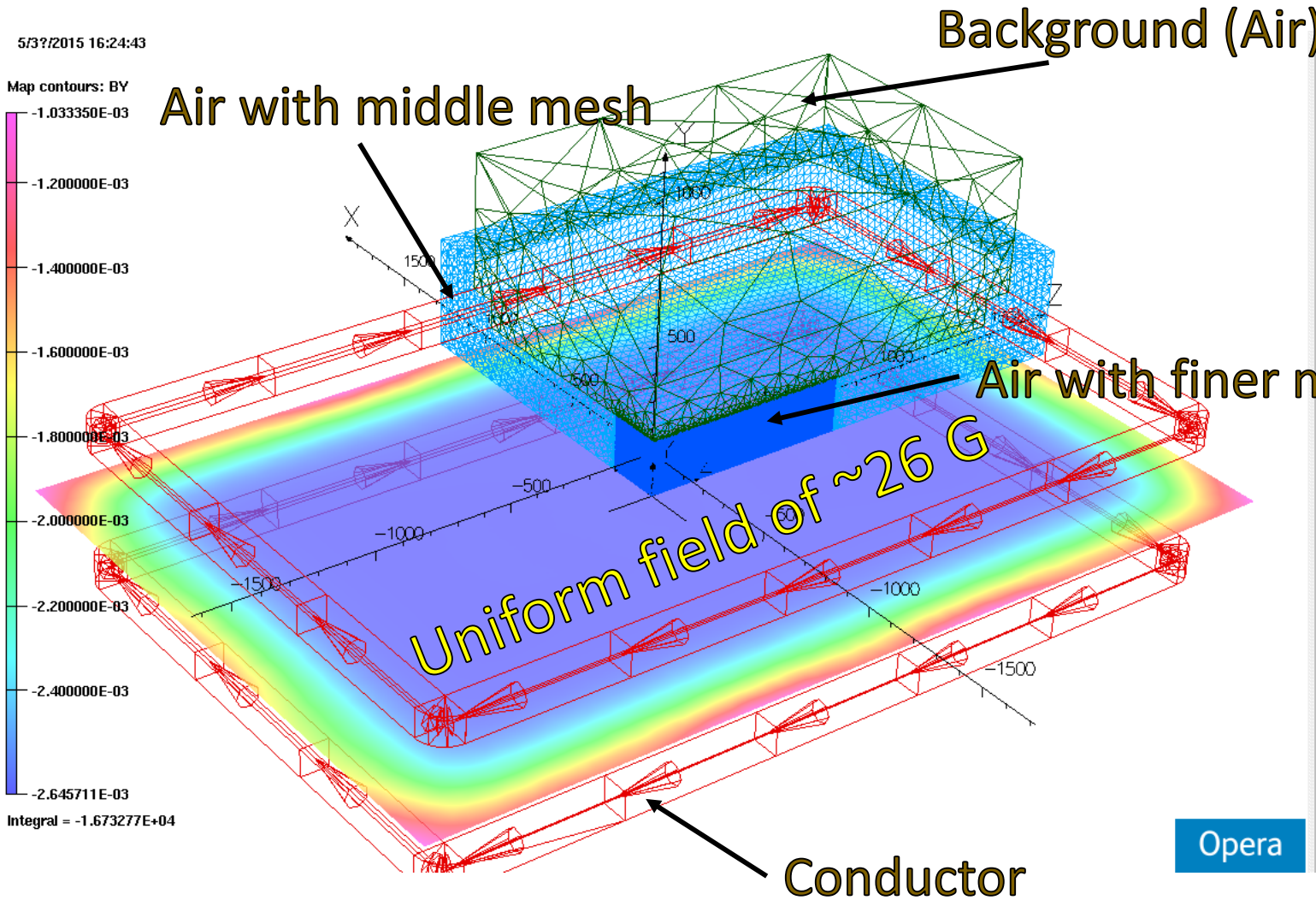
Local = Global

FIELD EVALUATIONS

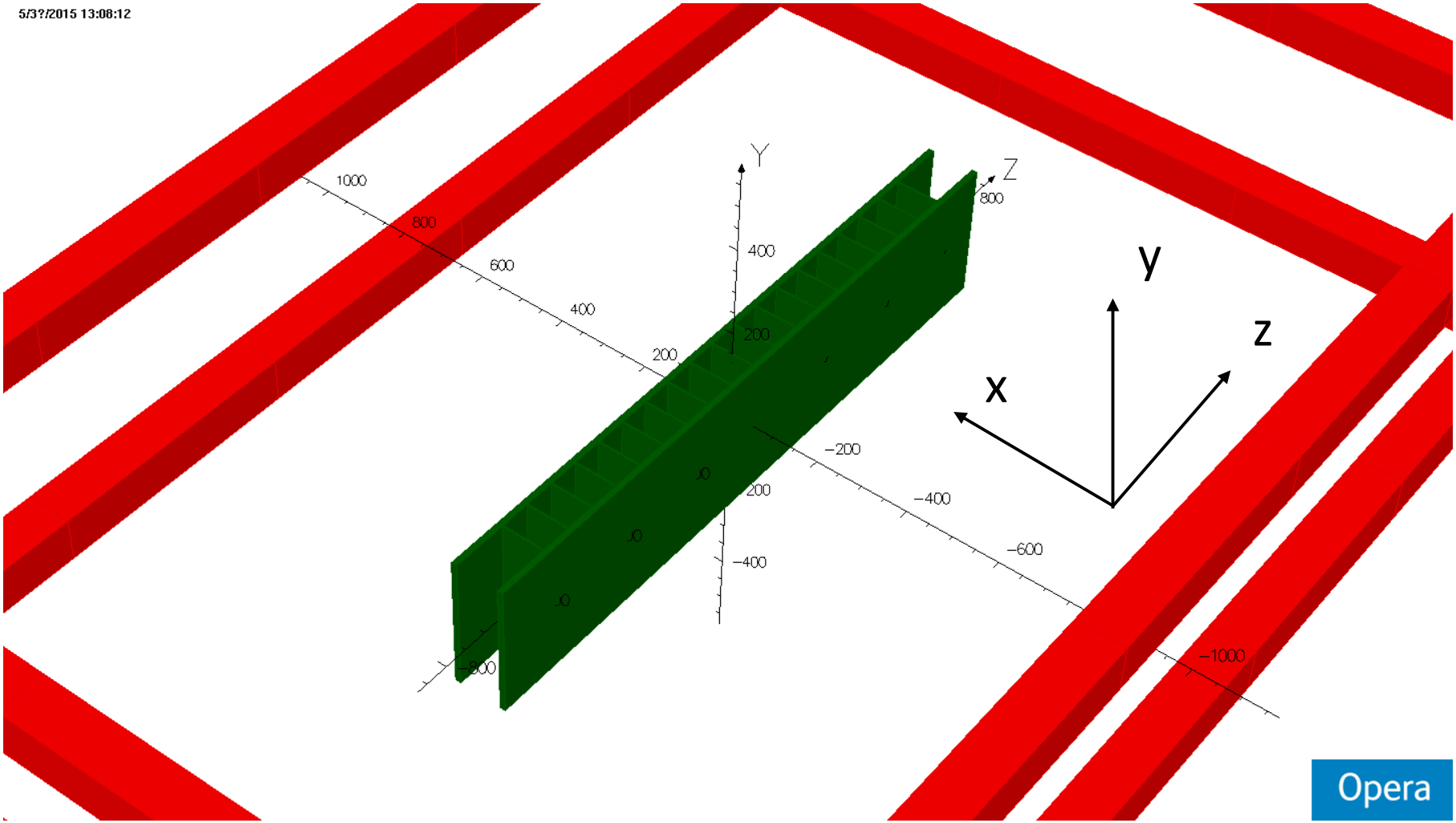
Line	LINE (nodal)	301	Cartesian
	x=40.0	y=-150.0 to 150.0	z=587.4
Cartesian	CARTESIAN (nodal)	200x200	Cartesian
	x=-1100.0 to 1100.0	y=0.0	z=-1600.0 to 1600.0

大体、S-2Sの漏れ磁場がこれくらいなので、
さし当りこの設定でスタディを進めました。

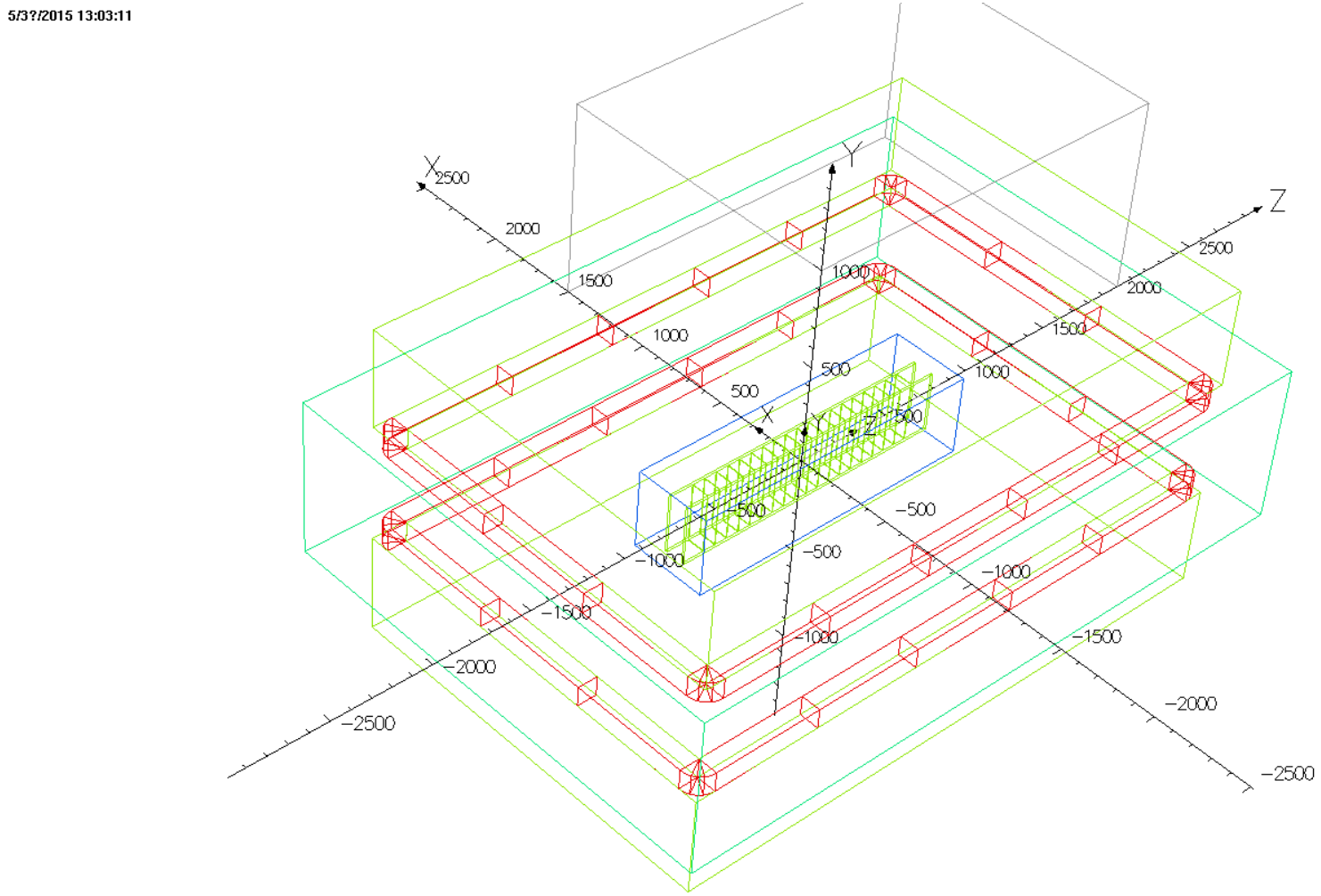
Electromagnet in TOSCA model



Put iron shield in the electromagnet



Whole design in modeler

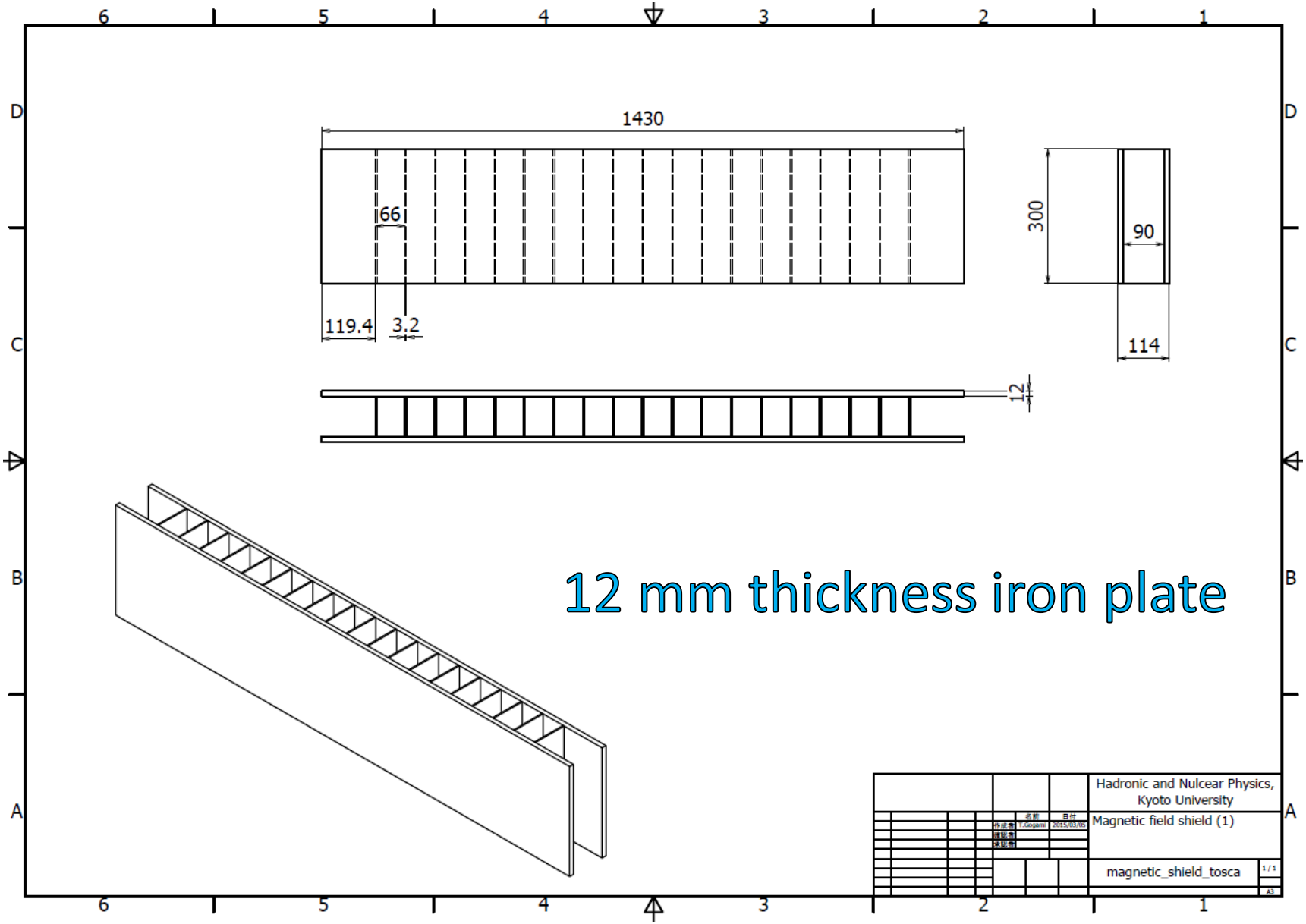


Opera

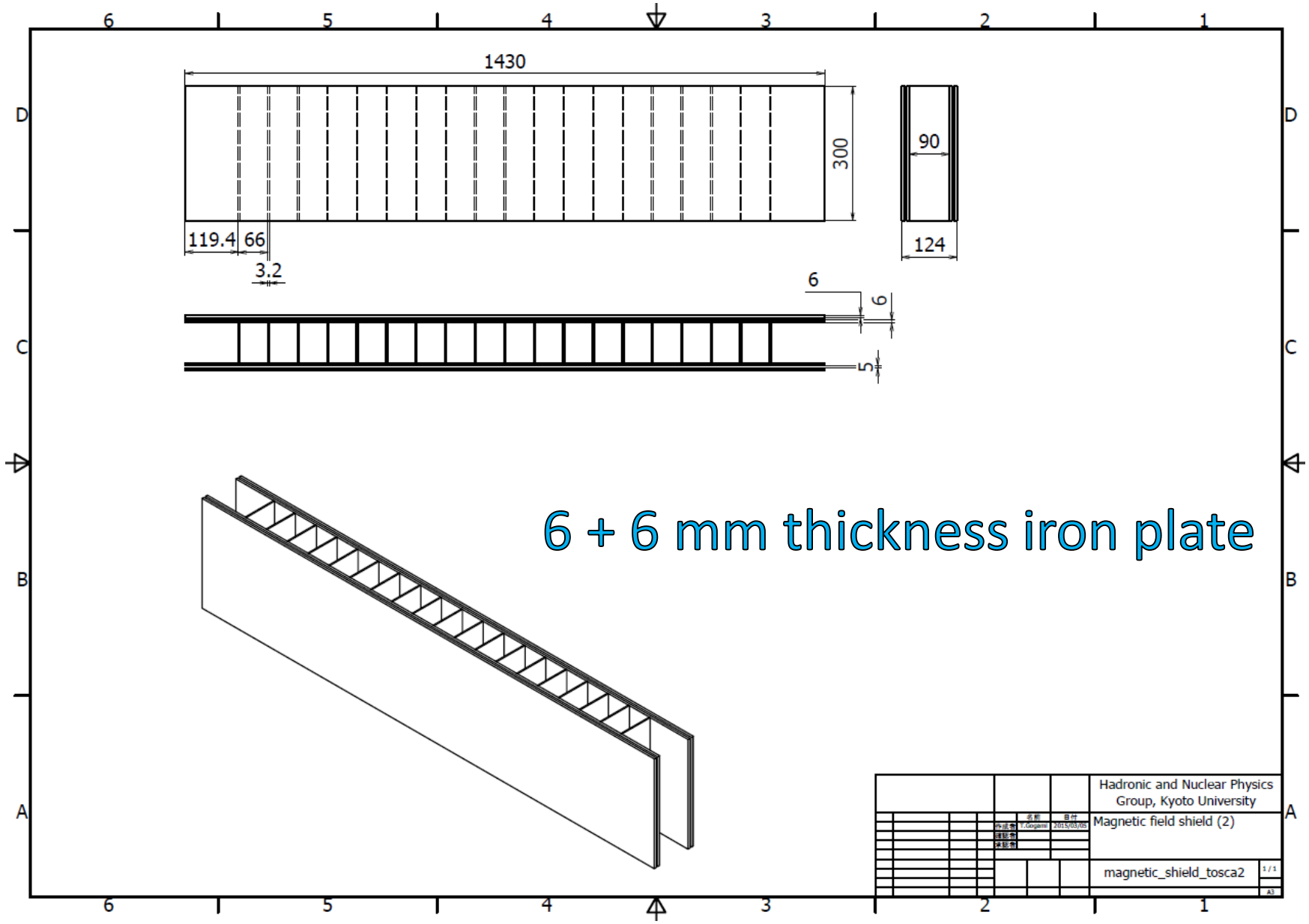
Tested shield models

1. 12 mm iron plate
2. 6 + 6 mm iron plate
3. 12 mm iron plate + 1 mm iron tube

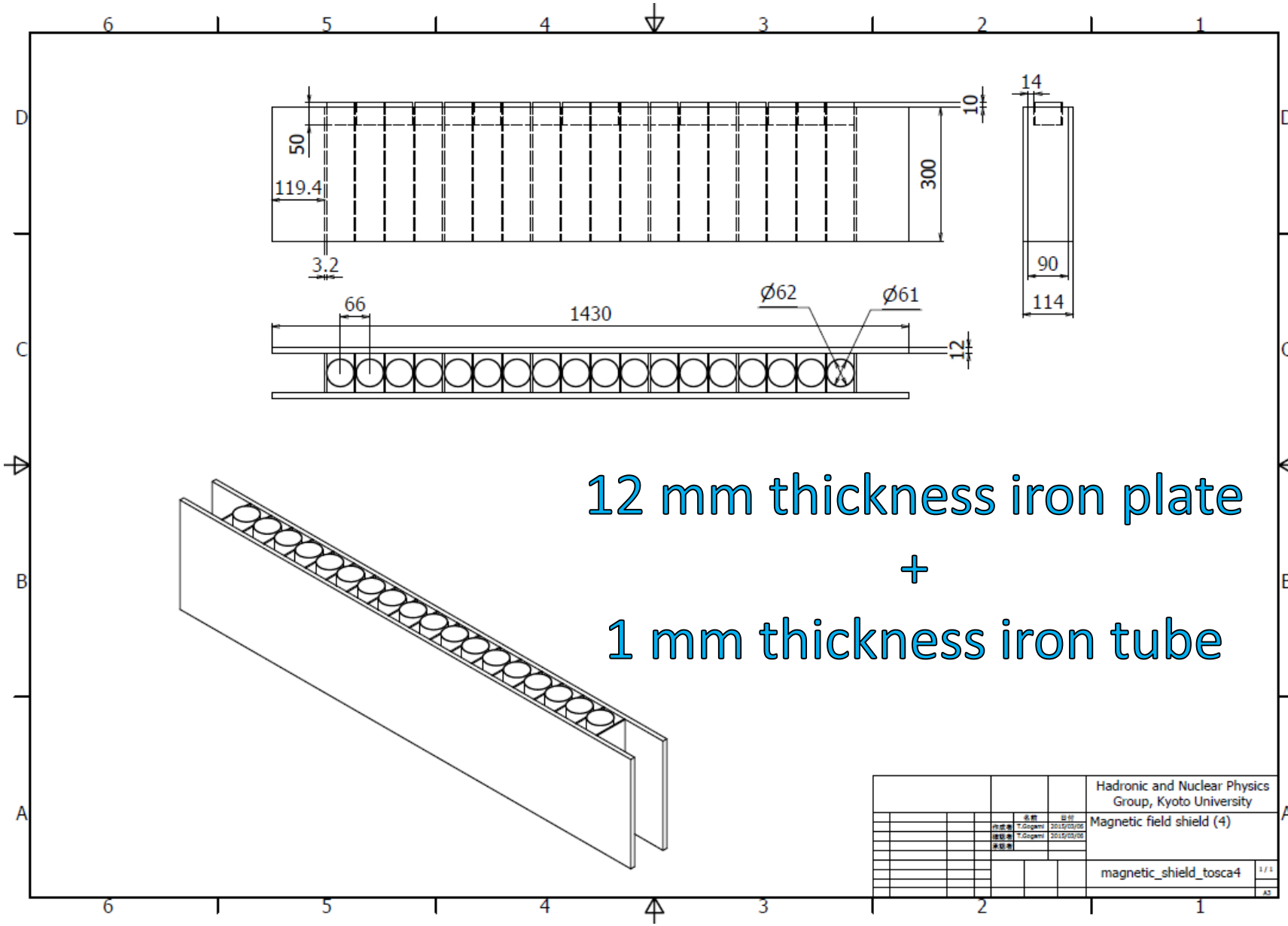
Tested model (1)



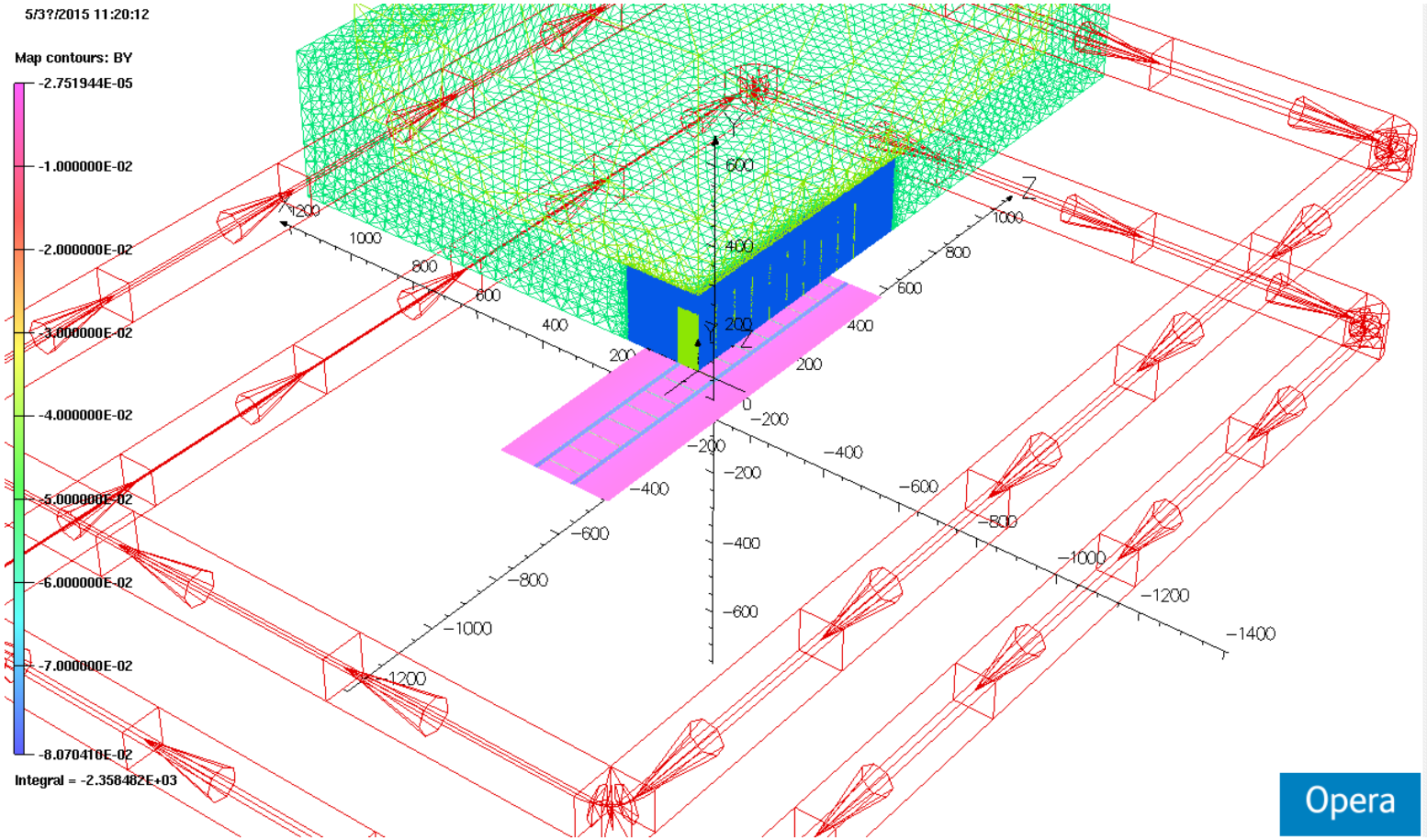
Tested model (2)



Tested model (3)



Post-processor (Configuration1)



UNITS

Length	mm
Magn Flux Density	T
Magnetic Field	A m^{-1}
Magn Scalar Pot	A
Current Density	A mm^{-2}
Power	W
Force	N

MODEL DATA

test_magnet_20_with_shield.op3
TOSCA Magnetostatic
Linear materials
Simulation No 1 of 1
9724018 elements
1636563 nodes
3 conductors
Nodally interpolated fields
Activated in global coordinates
Reflection in XY plane (Z field=0)
Reflection in YZ plane (X field=0)
Reflection in ZX plane (Z+X fields=0)

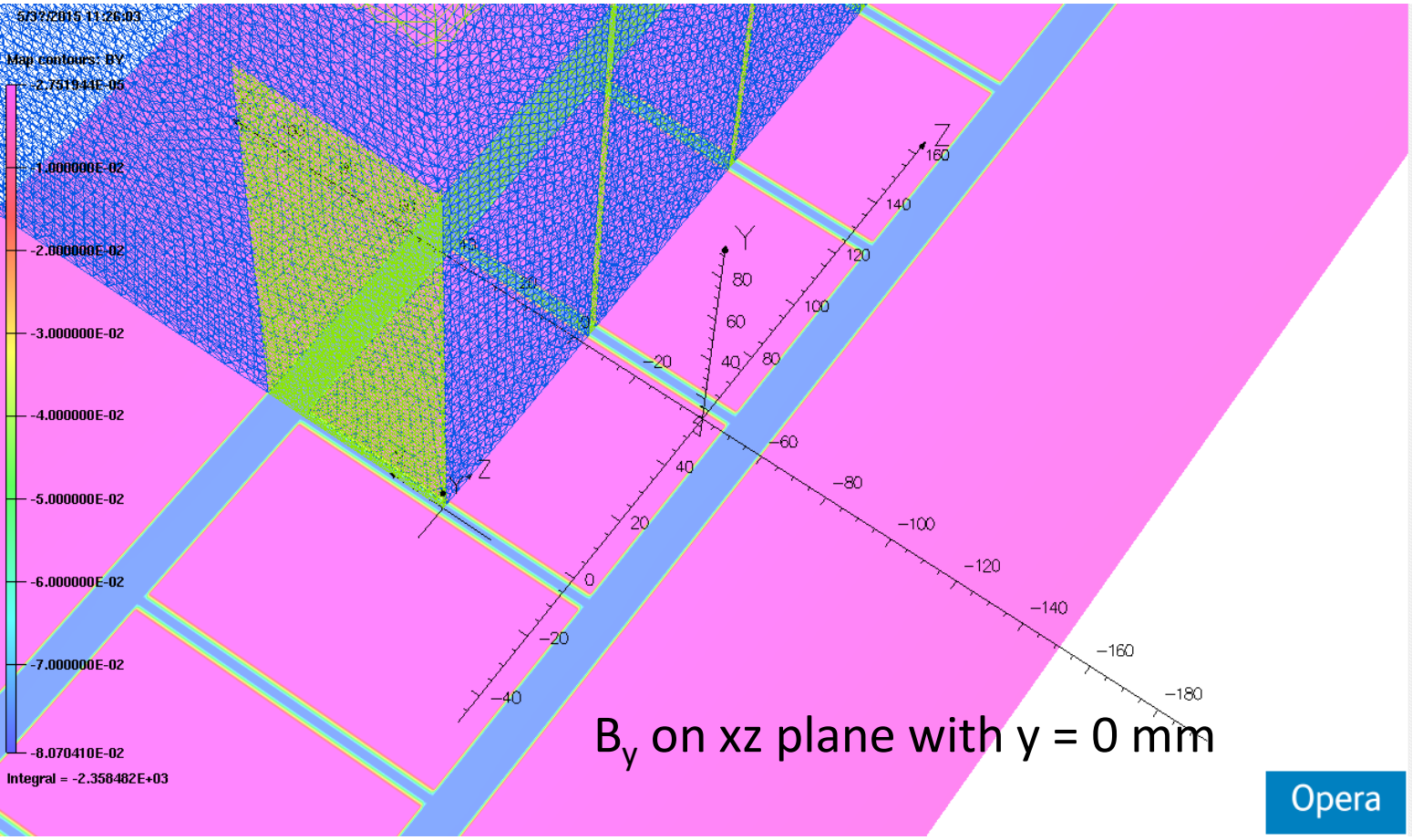
Field Point Local Coordinates

Local = Global

FIELD EVALUATIONS

Cartesian	CARTESIAN (nodal)	500x300	Cartesian
	x=-150.0 to 150.0	y=0.0	z=-500.0 to 500.0
Line	LINE (nodal)	301	Cartesian
	x=-30.0 to 30.0	y=0.0	z=33.0

Post-processor (Configuration1)



UNITS

Length	mm
Magn Flux Density	T
Magnetic Field	A m^{-1}
Magn Scalar Pot	A
Current Density	A mm^{-2}
Power	W
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MODEL DATA

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3 conductors
Nodally interpolated fields
Activated in global coordinates
Reflection in XY plane (Z field=0)
Reflection in YZ plane (X field=0)
Reflection in ZX plane (Z+X fields=0)

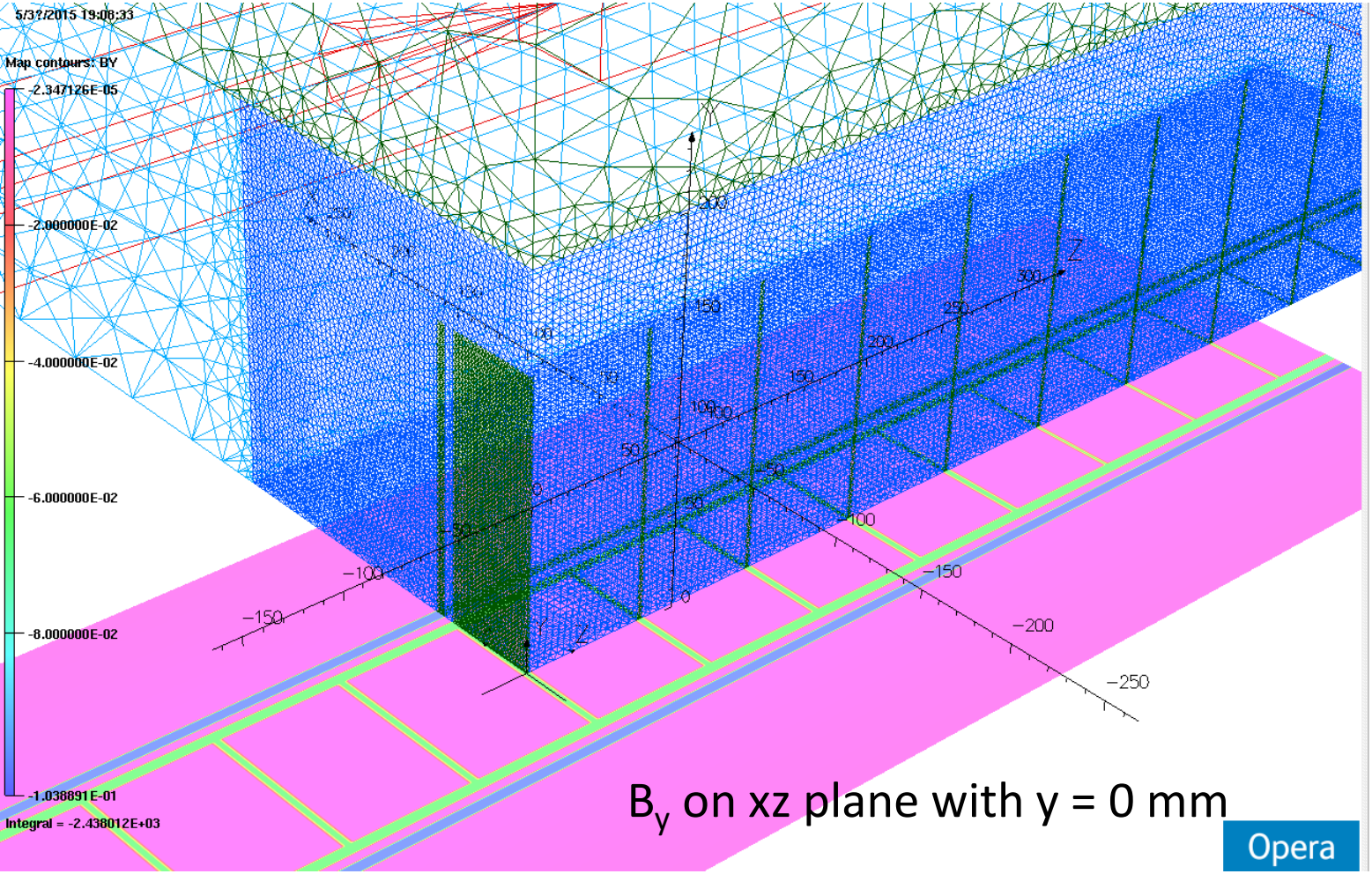
Field Point Local Coordinates

Local = Global

FIELD EVALUATIONS

Cartesian	CARTESIAN (nodal)	500x300	Cartesian
	x=-150.0 to 150.0	y=0.0	z=-500.0 to 500.0
Line	LINE (nodal)	101	Cartesian
	x=0.0	y=0.0	z=-10.0 to 10.0

Post-processor (Configuration2)



UNITS

Length	mm
Magn Flux Density	T
Magnetic Field	A m^{-1}
Magn Scalar Pot	A
Current Density	A mm^{-2}
Power	W
Force	N

MODEL DATA

test_magnet_20_with_shield2.op3
TOSCA Magnetostatic
Linear materials
Simulation No 1 of 1
9395272 elements
1582051 nodes
3 conductors
Nodally interpolated fields
Activated in global coordinates
Reflection in XY plane (Z field=0)
Reflection in YZ plane (X field=0)
Reflection in ZX plane (Z+X fields=0)

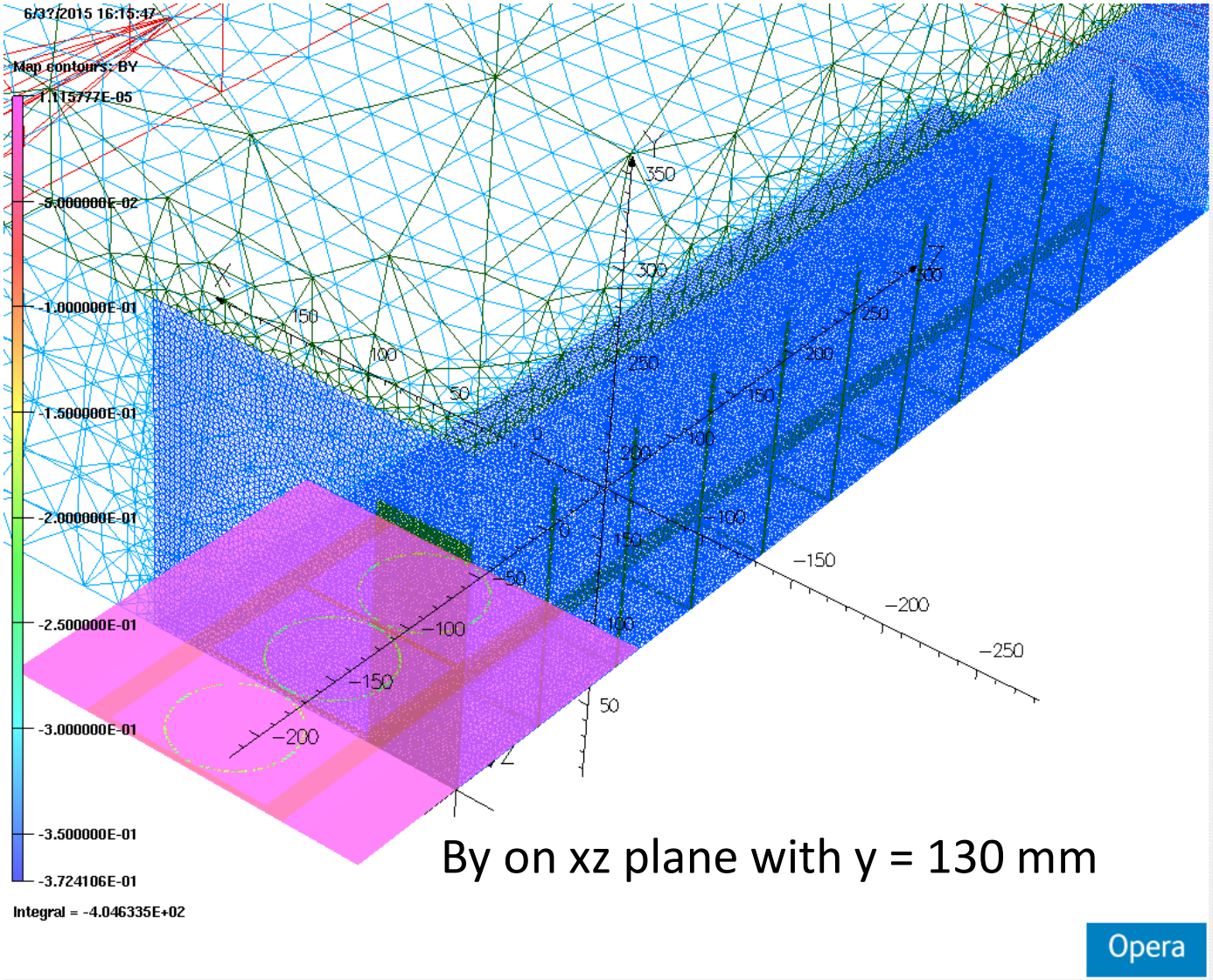
Field Point Local Coordinates

Local = Global

FIELD EVALUATIONS

Cartesian	CARTESIAN (nodal)	500x300	Cartesian
	x=-150.0 to 150.0	y=0.0	z=-500.0 to 500.0

Post-processor (Configuration3)



By on xz plane with y = 130 mm

UNITS

Length	mm
Magn Flux Density	T
Magnetic Field	A m^{-1}
Magn Scalar Pot	A
Current Density	A mm^{-2}
Power	W
Force	N

MODEL DATA

test_magnet_20_with_shield4.op3
TOSCA Magnetostatic
Linear materials
Simulation No 1 of 1
10086825 elements
1964499 nodes
3 conductors
Nodally interpolated fields
Activated in global coordinates
Reflection in XY plane (Z field=0)
Reflection in YZ plane (X field=0)
Reflection in ZX plane (Z+X fields=0)

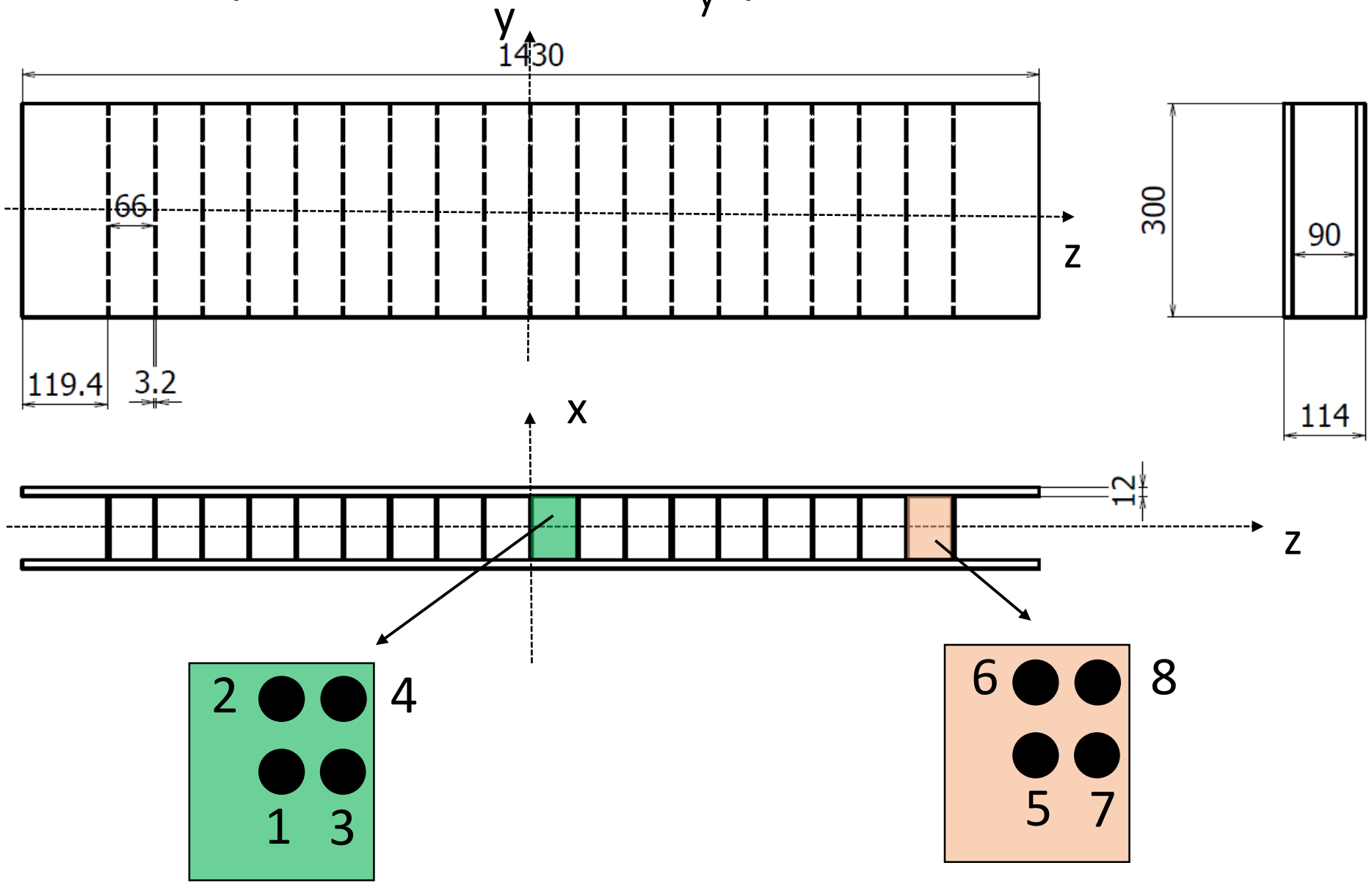
Field Point Local Coordinates

Local = Global

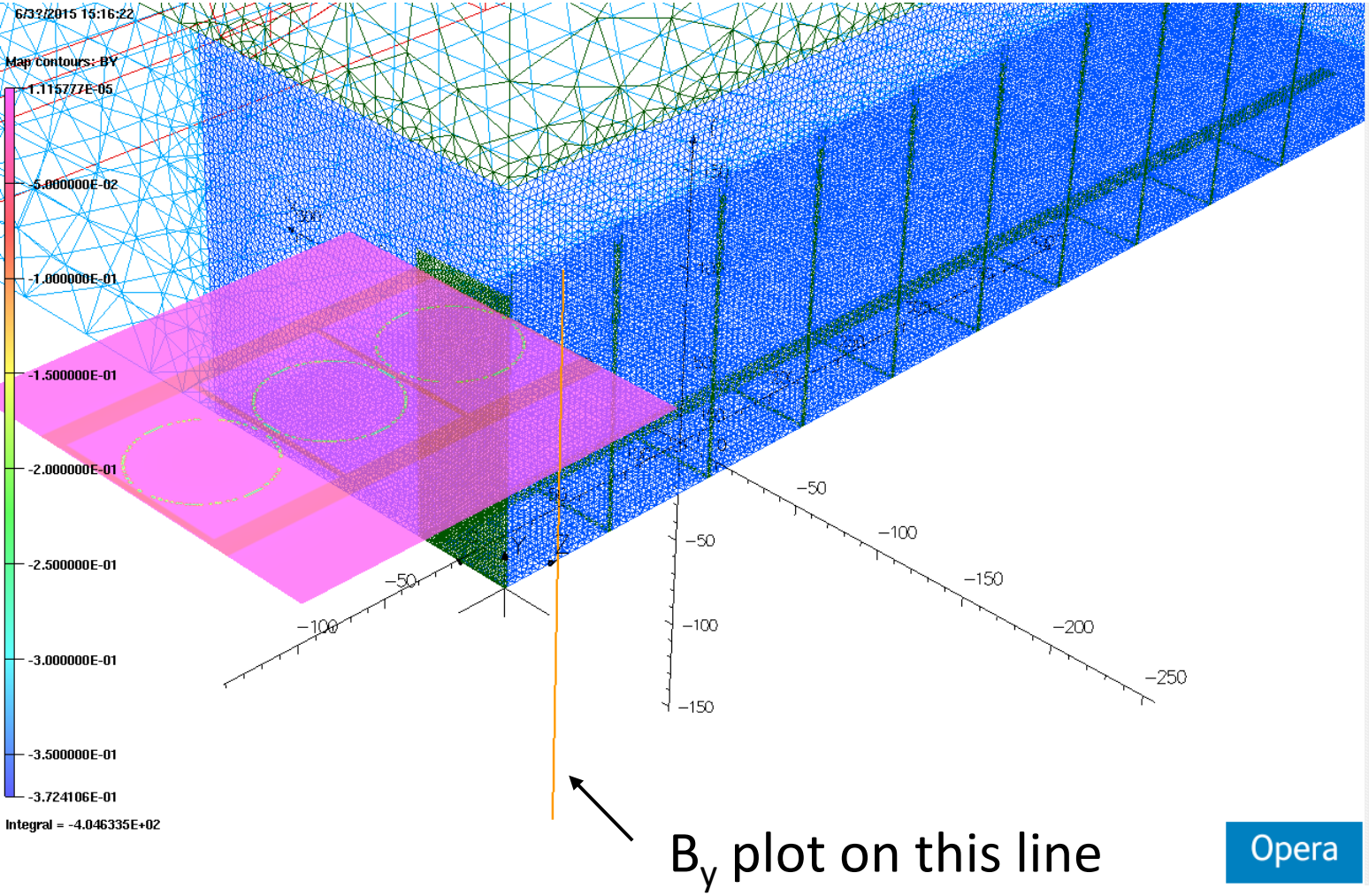
FIELD EVALUATIONS

Cartesian	CARTESIAN (nodal)	200x20 0 x=-100.0 to 100.0	Cartesian y=140. 0 z=-200.0 to 0.0

Sample lines for B_y plot



Example
(Configuration3 + Line1)



UNITS

Length	mm
Magn Flux Density	T
Magnetic Field	A m^{-1}
Magn Scalar Pot	A
Current Density	A mm^{-2}
Power	W
Force	N

MODEL DATA

test_magnet_20_with_shield4.op3
TOSCA Magnetostatic
Linear materials
Simulation No 1 of 1
10086825 elements
1964499 nodes
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Nodally interpolated fields
Activated in global coordinates
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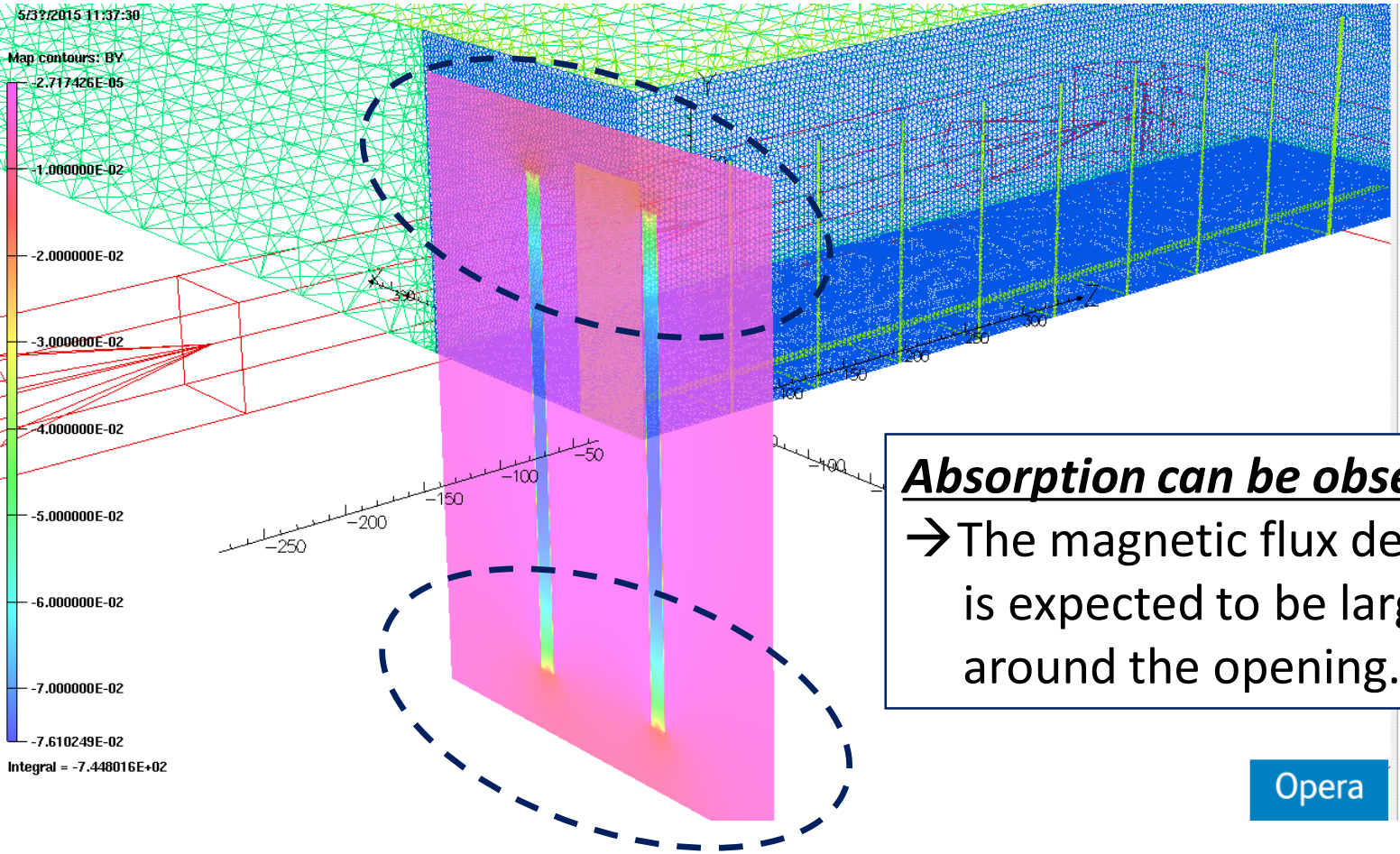
Field Point Local Coordinates

Local = Global

FIELD EVALUATIONS

Cartesian	CARTESIAN (nodal)	200x200	Cartesian
	x=-100.0 to 100.0	y=140.0	z=-200.0 to 0.0
Line	LINE (nodal)	301	Cartesian
	x=0.0	y=-150.0 to 150.0	z=33.0

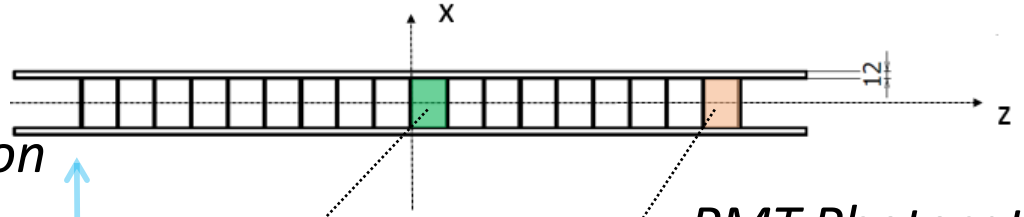
Expectation from the 2D Contour plot



Absorption can be observed !!

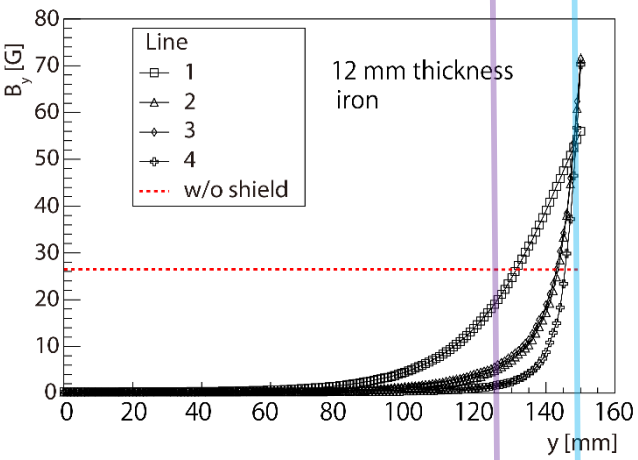
→The magnetic flux density is expected to be large around the opening.

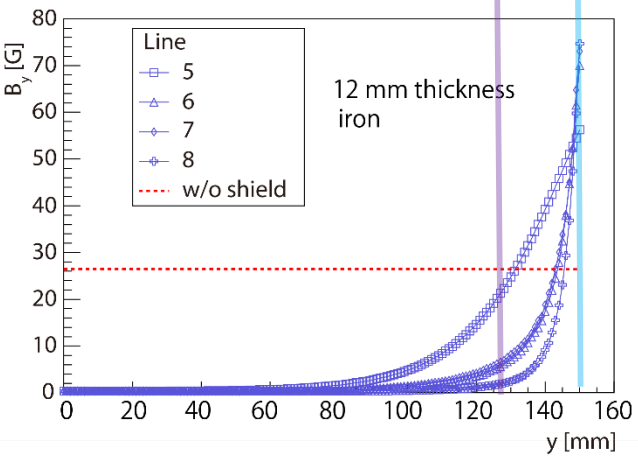
Position dependence (Configuration1)



Edge of iron

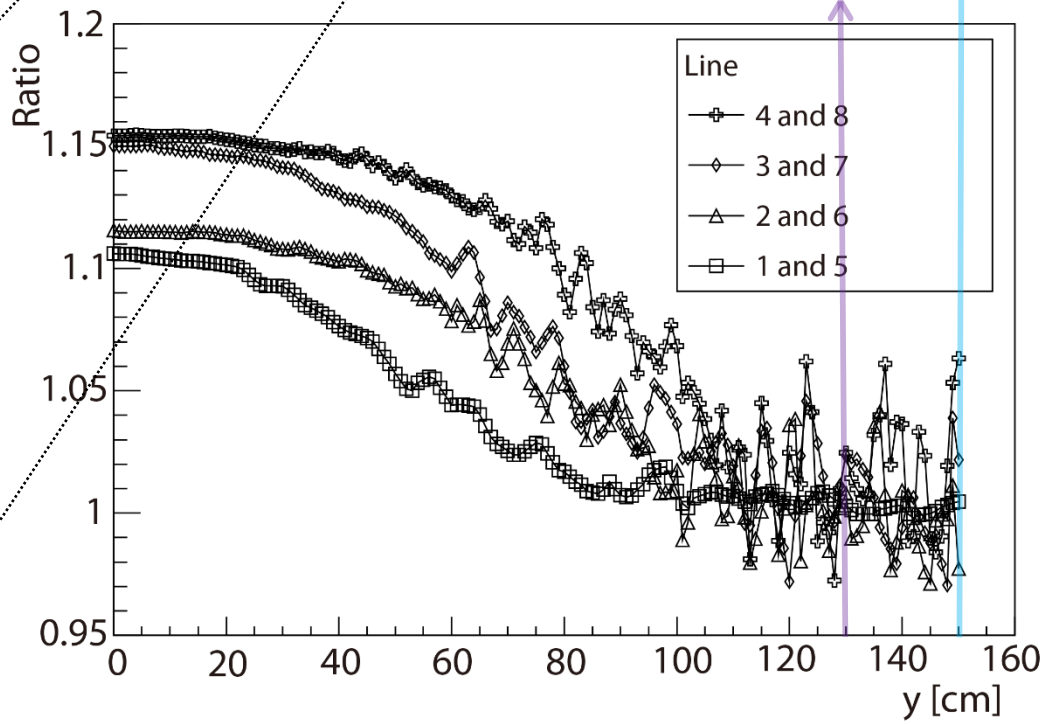
PMT Photocathode





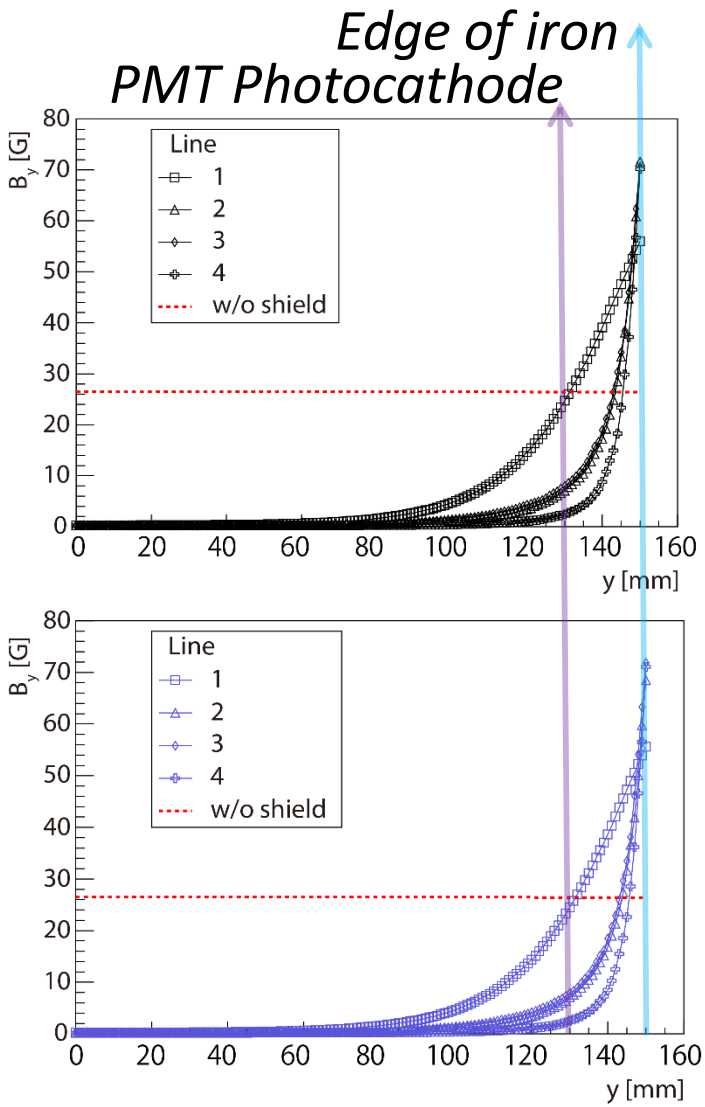
Edge of iron

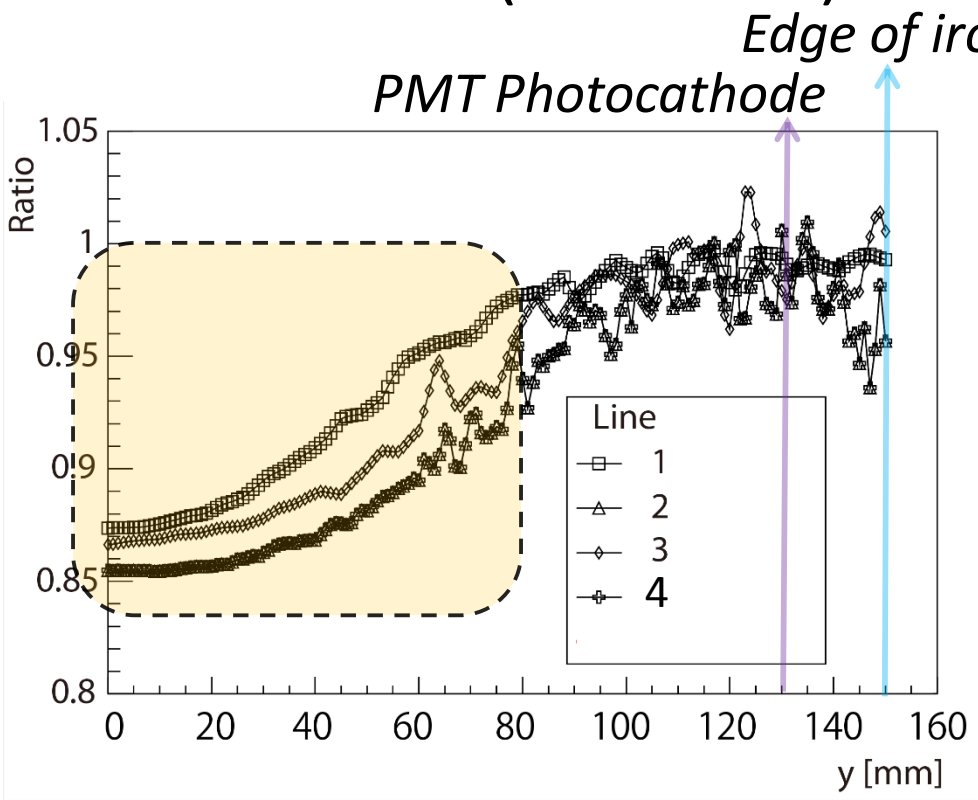
PMT Photocathode



B_y of 1,2,3 and 4 are larger than those of 5,6,7 and 8.

Configuration difference
12 mm (Conf. 1) vs. 6+6 mm (Conf. 2)



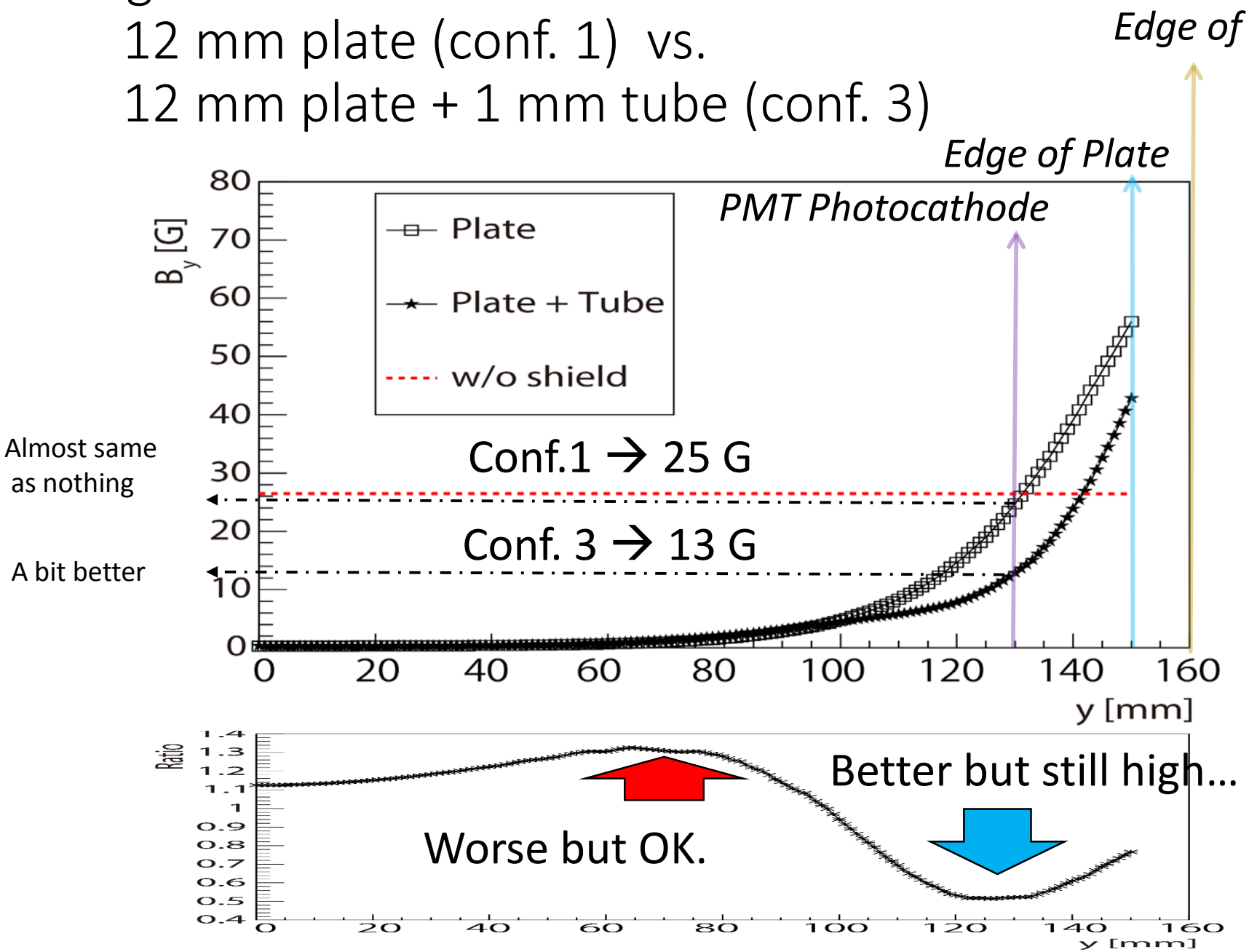


Shield effect of configuration 2
is better around center
though the absolute value is small.

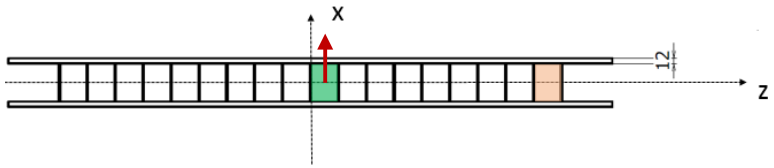
Configuration difference on line1:

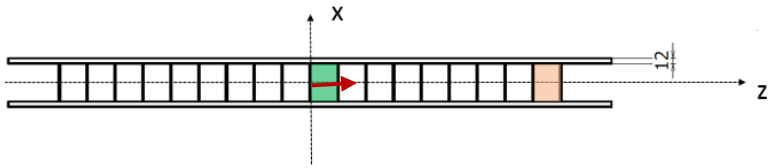
12 mm plate (conf. 1) vs.

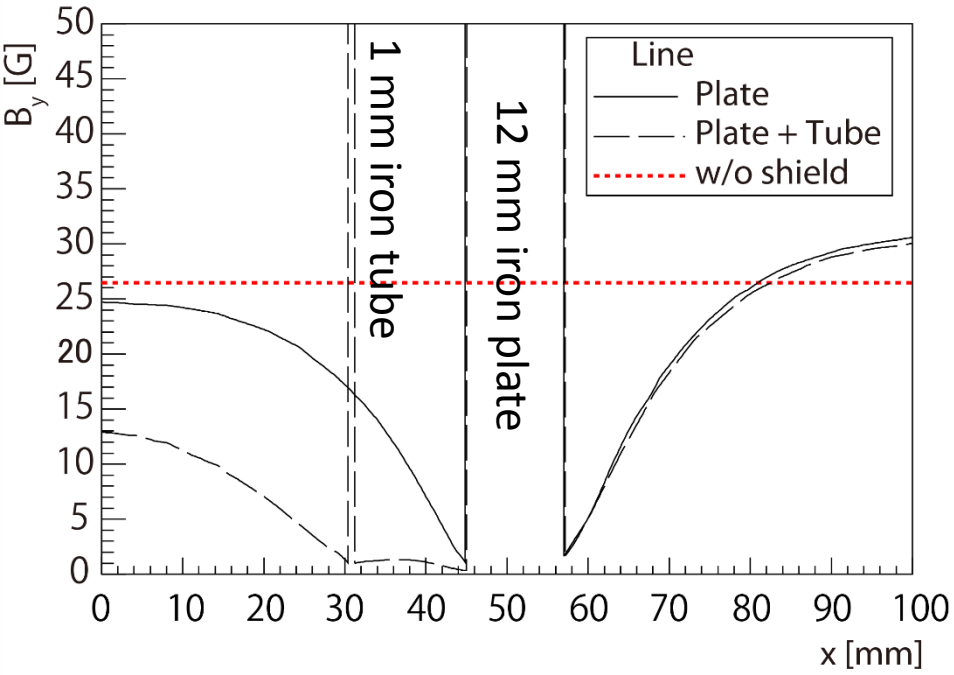
12 mm plate + 1 mm tube (conf. 3)



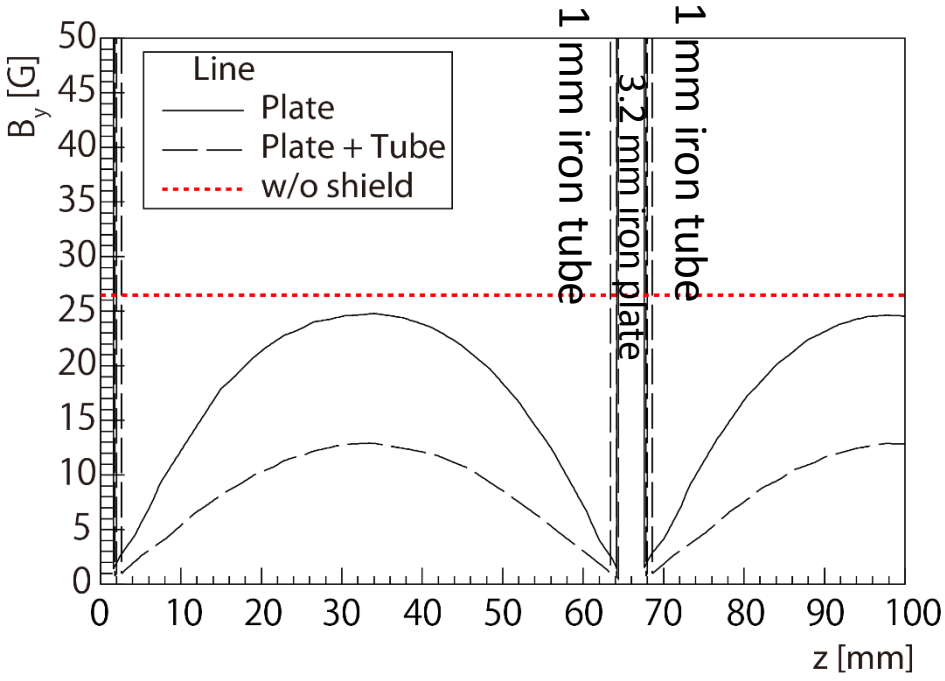
x and *z* dependences for conf. 1 and conf. 3







(y,z) = (0,33)



(x,y) = (0,0)

Summary

本文に無いですが

- 先行研究*(径が一緒のH7195のスタディ):
  - 管軸方向磁場5 G → ゲインが40% (60%減る)
  - PMT光電面から第一ダノード付近が特に磁場に弱い

  → **光電面付近で数ガウスに落としたい**

  (TOFに使用するH1195はゲインが良いので、
  そこまでしなくてもいいかもしれません。
  先行研究では10 Gでゲインが10%になる事が分かっています。
  つまり、10 Gくらいの環境下で普通のPMT(例えばH7195)
  くらいのゲインがでるはず。)

- もともと考えていたシールド使用時(Conf. 1)、
  PMT光電面付近でシールドが無いのと同じ。

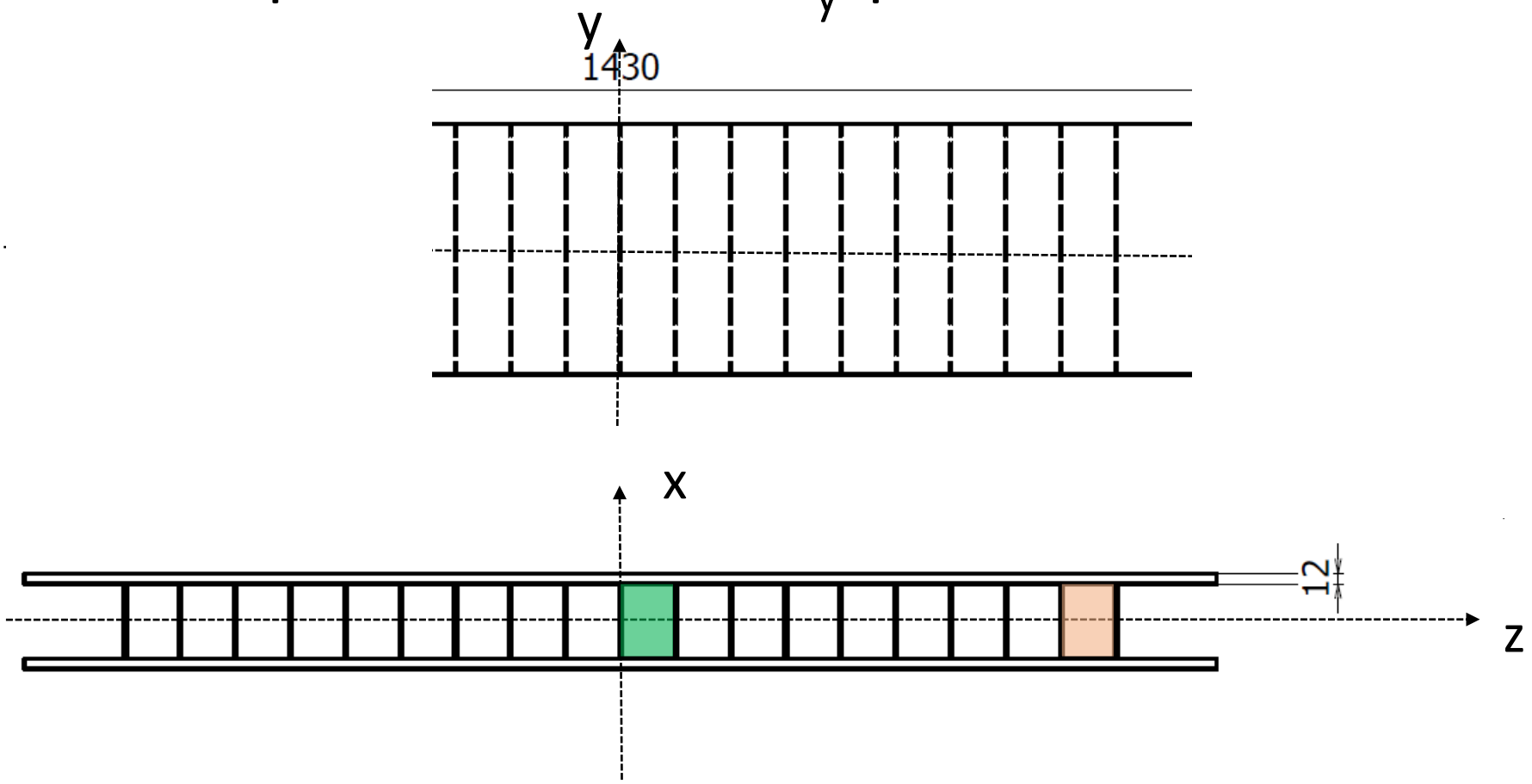
- 鉄板と鉄管の組み合わせ (Conf. 3)の場合には、
  PMT光電面付近で 26 G → 13 Gまで落とせる(鉄から遠いところ)。
  が、 少し不安。

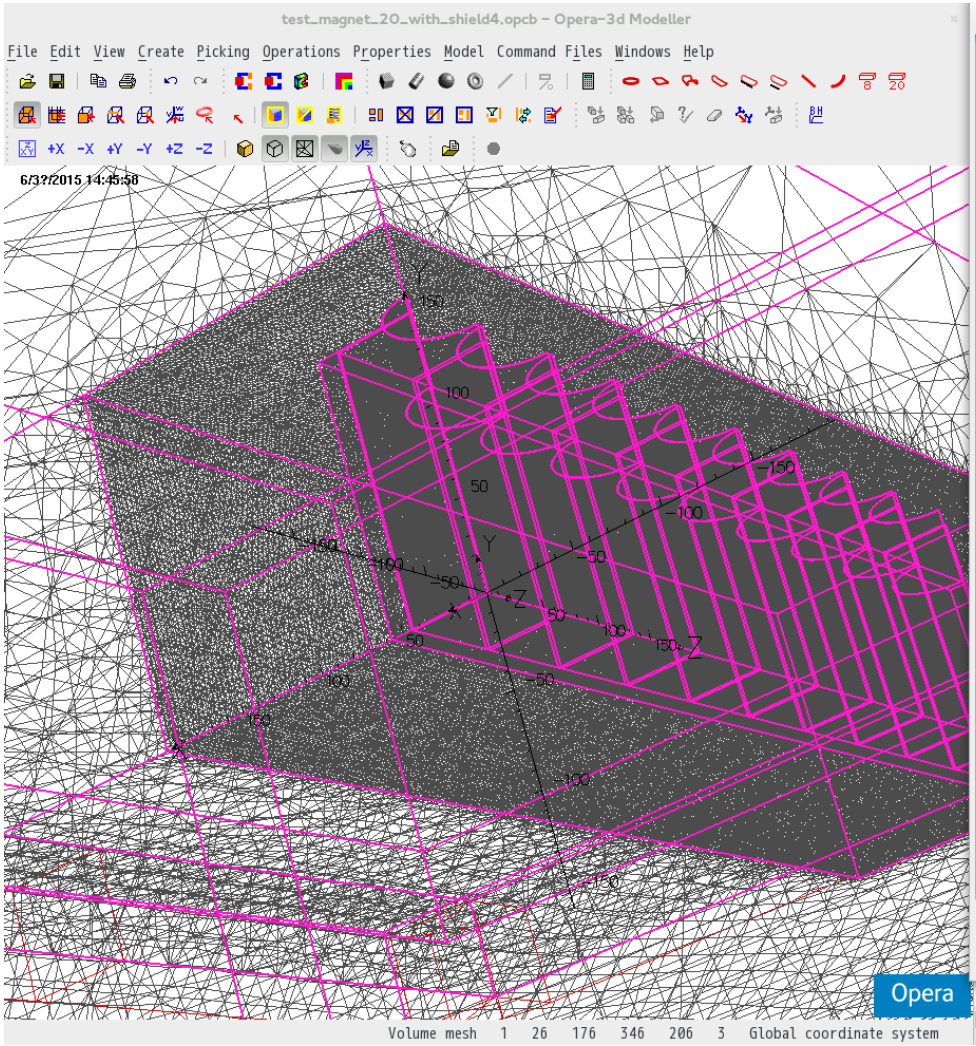
- PMTの(磁気シールドの)真ん中付近では、
  どの設定でも26 G → 0 Gに落とせる。

* T.Gogami et al. *NIMA***729**(2013)816-824

Backup

Sample lines for B_y plot





test_magnet_20_with_shield4.op3 (TOSCA analysis)

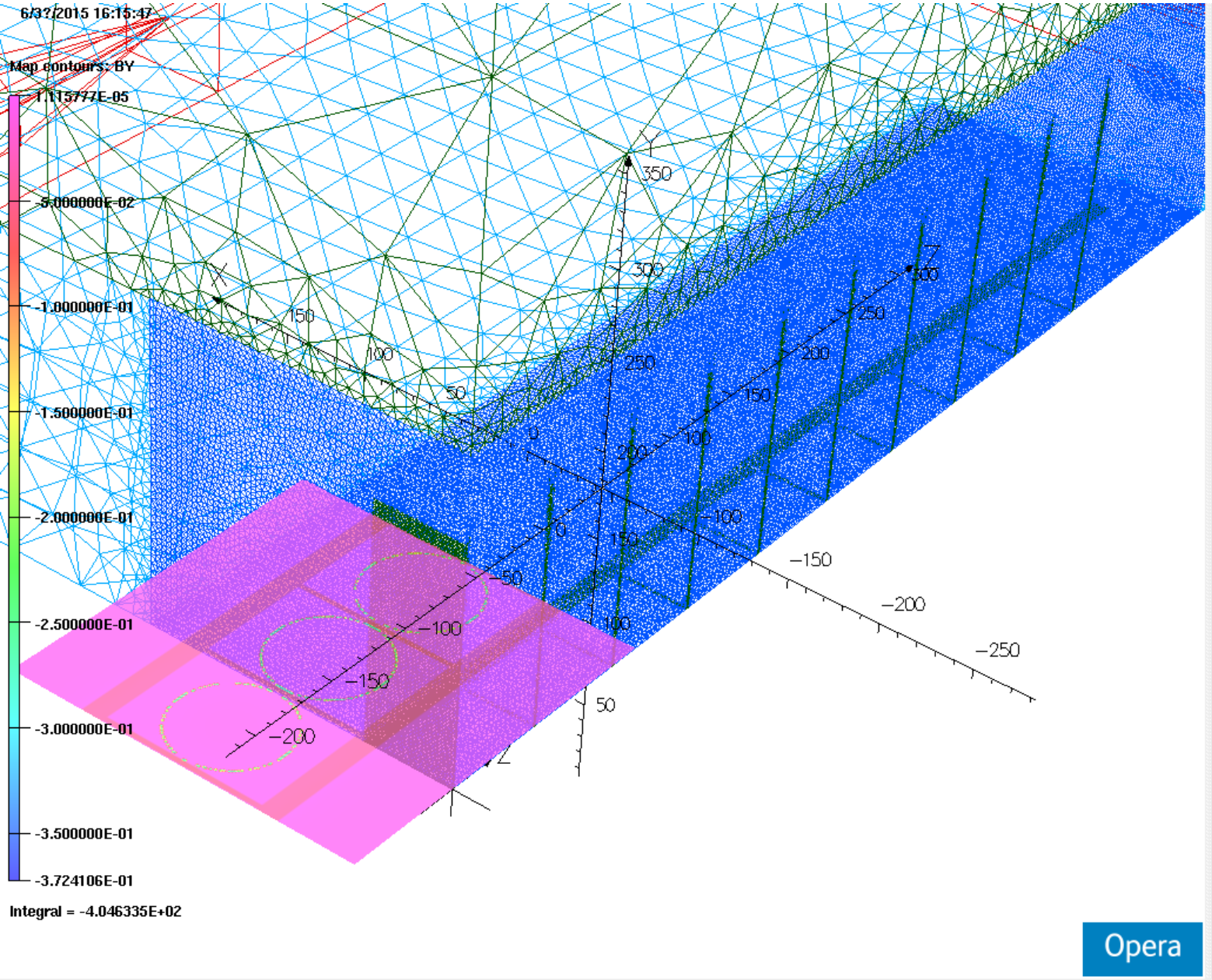
Current progress

```
TOSCA Magnetostatic analysis

File: test_magnet_20_with_shield4.op3 simulation:  1
Created on: 06/Mar/2015 14:44:53
In Directory: /home/dragon/tosca/tof_shield/
By Machine: Node: hyperdragon3. Processor: x86_64. System: Linux. version 3.18.7-100.
Log Files: Modeller_20150306132655912l.log/lp
Simulation created using: Opera-3d/Modeller Version 15.0.27114
User did not enter a title

SI(millimetre) units

3 Biot-Savart conductors (current densities in A mm**-2):
    1 Arc
    Current Densities: 20.0
    2 Straights
    Current Densities: 20.0
Adaptive RHS integrals
Drive sets and functions
DEFAULT_DRIVE    : Coil drive type Constant

Boundary Conditions: NORMMAGN TANGMAGN

Linear solution
No periodicity conditions have been defined

Materials defined:
IRON
  Isotropic permeability: /data/data1/dragon/tool/opera/Opera_15/bh/tenten.bh (2754.5
DAIR
  Isotropic permeability: 1.0
AIR1
  Isotropic permeability: 1.0
AIR


1964499 nodes in the model
11817027 edges in the model
Both linear and quadratic elements exist in the model
9891251 linear tetrahedra
195574 quadratic tetrahedra
Total 10086825 elements
```

Close Window | Stop Analysis | Post-Process

| 1 | 48 Common: 0 | 0 | 0 Total: 0 | 1 | 48

Widgets-CRITICAL **: gimp_device_info_set_devi
LL && GDK_IS_DEVICE (device)) || (GDK_IS_DEVIC
)' failed



UNITS

Length	mm
Magn Flux Density	T
Magnetic Field	A m^{-1}
Magn Scalar Pot	A
Current Density	A mm^{-2}
Power	W
Force	N

MODEL DATA

test_magnet_20_with_shield4.op
3
TOSCA Magnetostatic
Linear materials
Simulation No 1 of 1
10086825 elements
1964499 nodes
3 conductors
Nodally interpolated fields
Activated in global coordinates
Reflection in XY plane (Z field=0)
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Reflection in ZX plane (Z+X fields=0)

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Local = Global

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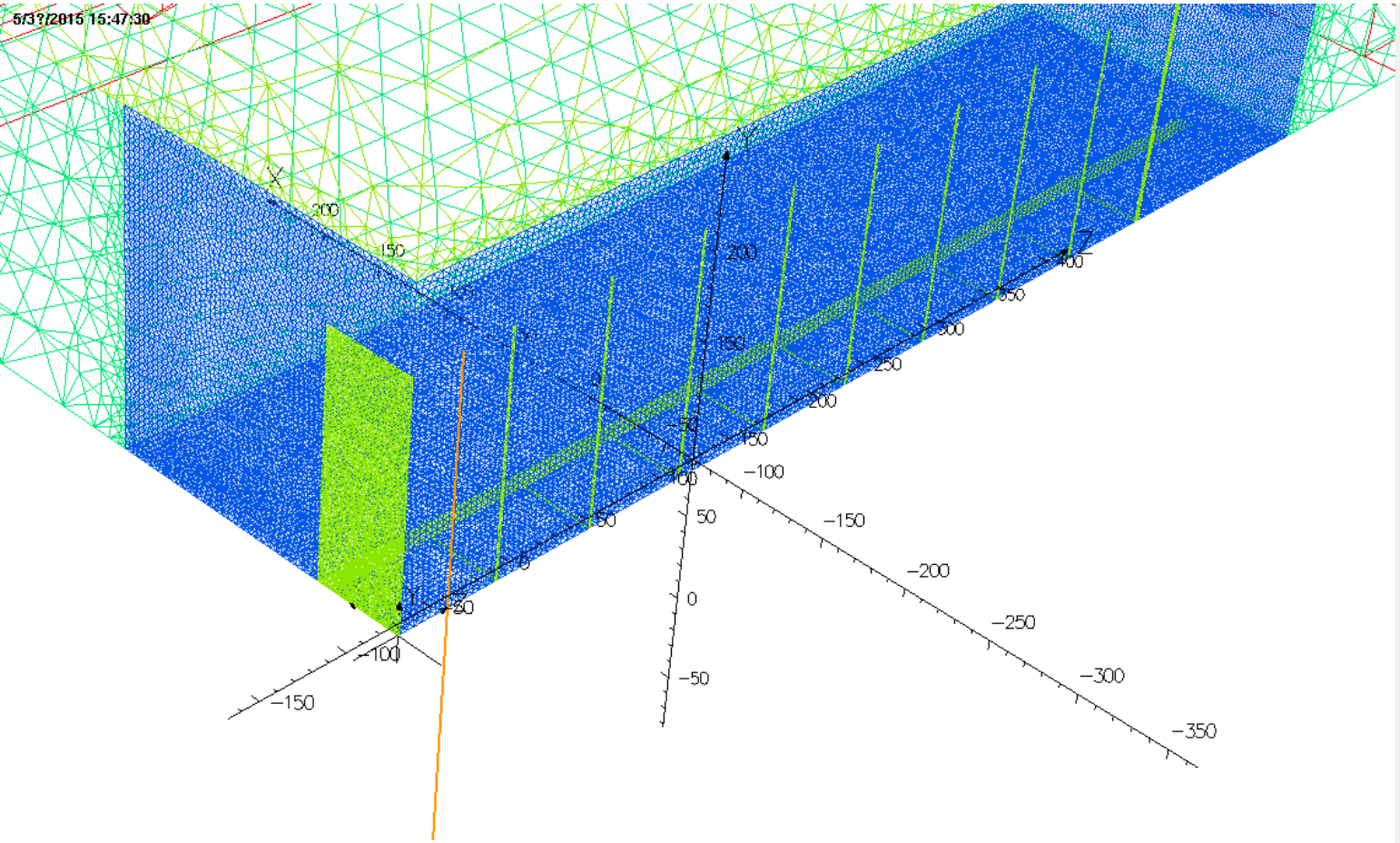

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Magnetic Field	A m^{-1}
Magn Scalar Pot	A
Current Density	A mm^{-2}
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TOSCA Magnetostatic
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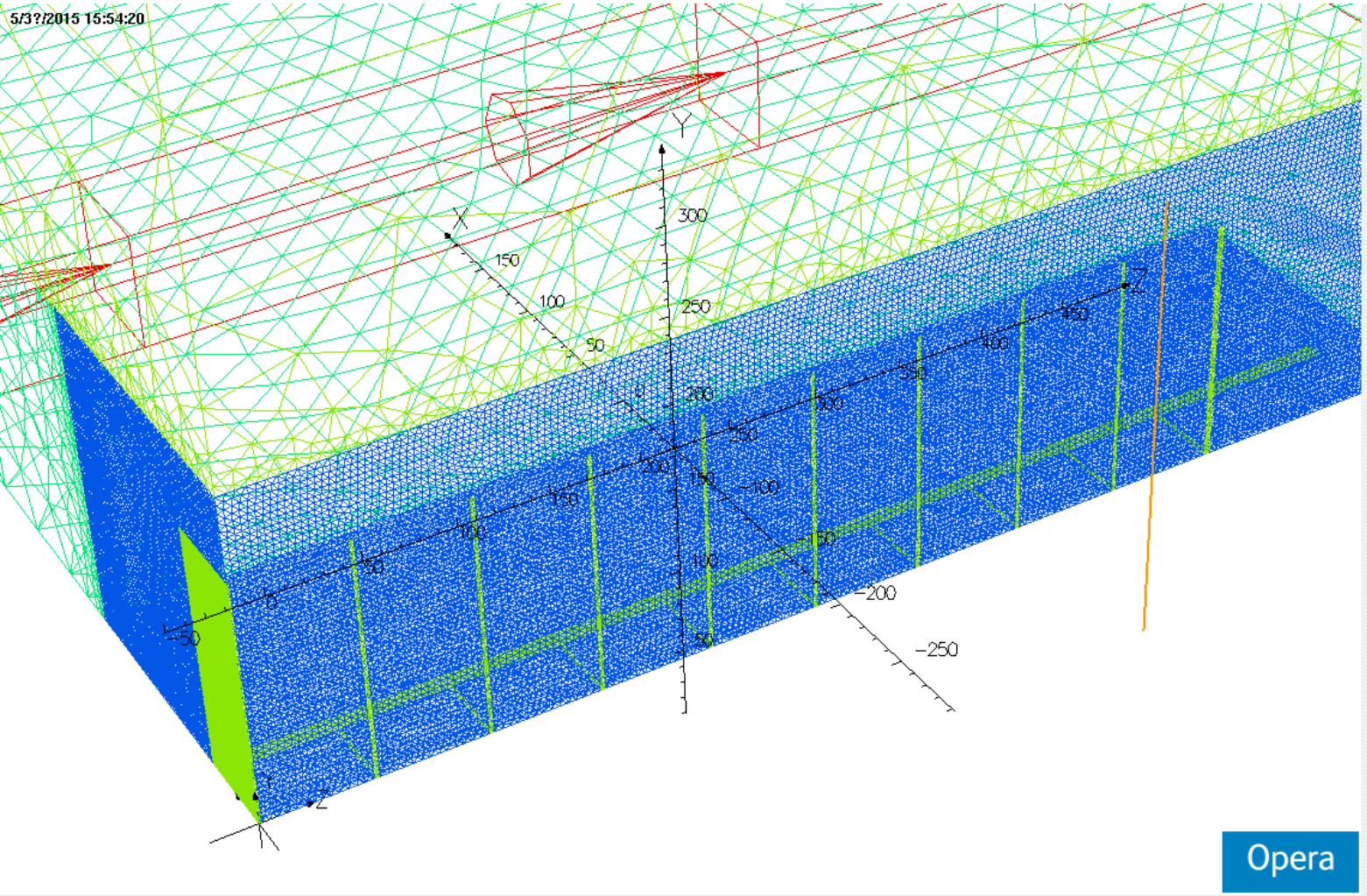
Reflection in YZ plane (X field=0)
Reflection in ZX plane (Z+X fields=0)

Field Point Local Coordinates

Local = Global

FIELD EVALUATIONS

Line	LINE (nodal)	301	Cartesian
	x=0.0	y=-150.0 to 150.0	z=33.0



UNITS

Length	mm
Magn Flux Density	T
Magnetic Field	A m^{-1}
Magn Scalar Pot	A
Current Density	A mm^{-2}
Power	W
Force	N

MODEL DATA

test_magnet_20_with_shield.op3
TOSCA Magnetostatic
Linear materials
Simulation No 1 of 1
9724018 elements
1636563 nodes
3 conductors
Nodally interpolated fields
Activated in global coordinates
Reflection in XY plane (Z field=0)
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)	301	Cartesian
	x=40.0	y=-150.0 to 150.0	z=587.4