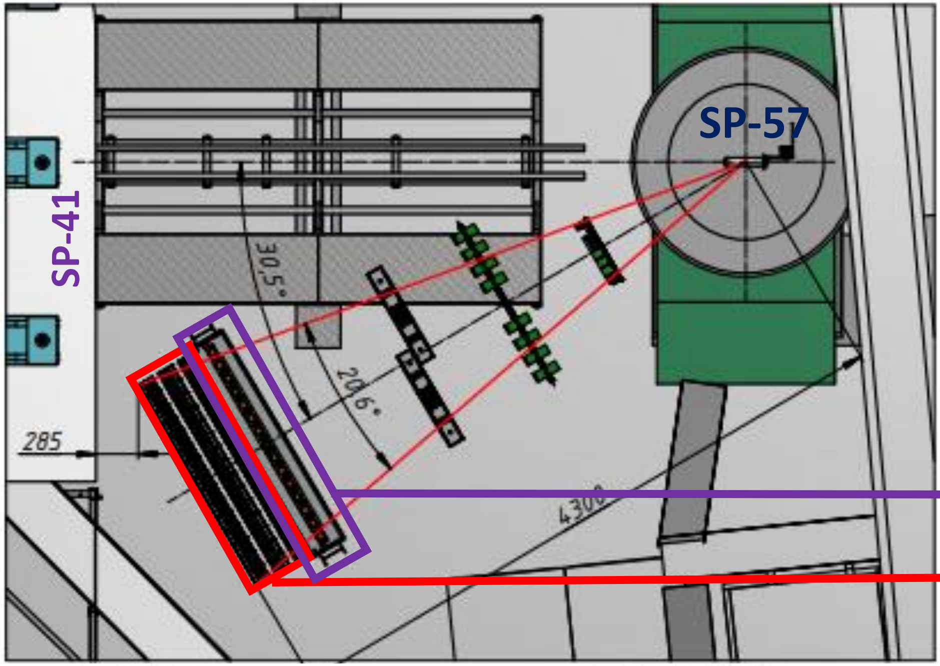
Simulation of magnetic shielding for PMTs next to the SP-41 magnet (SRC experiment)

Timur Atovullaev
Aleksey Shabunov

20th April 2021
7th Collaboration Meeting of the BM@N Experiment at the NICA Facility

Proton-pion calorimeter for SRC

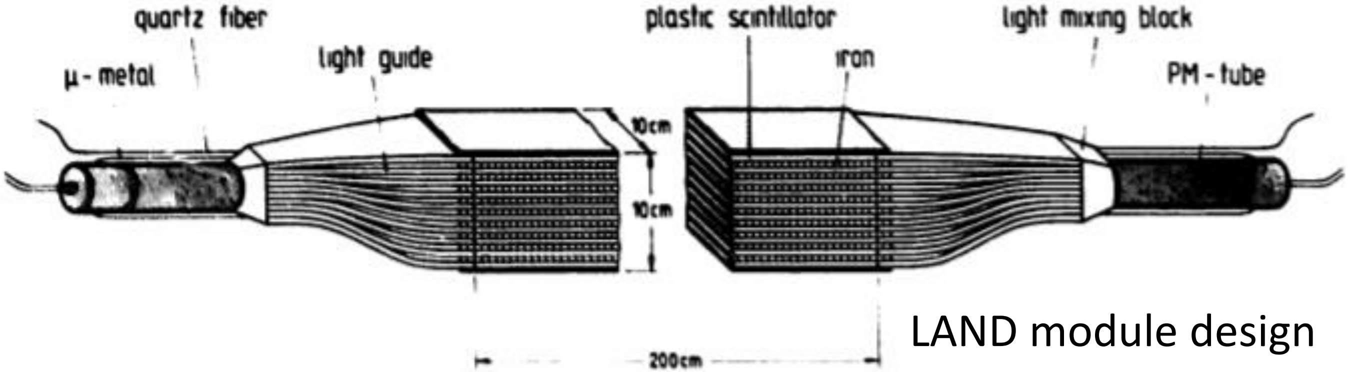


Calorimeter for proton-pion separation
LAND modules

TOF layer for time of flight measurements
6x10x200 cm^3 scintillator bars

1 layer TOF

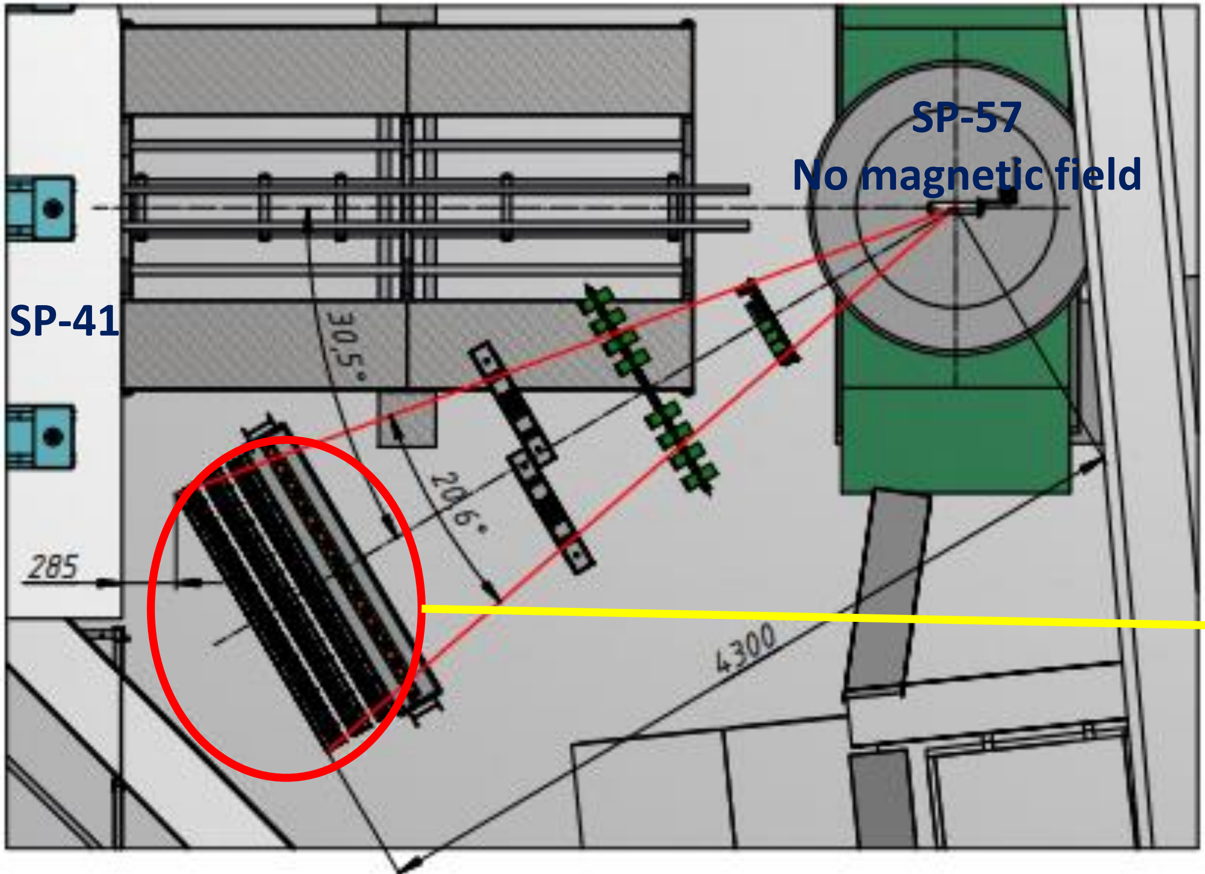
3 layers of LAND modules

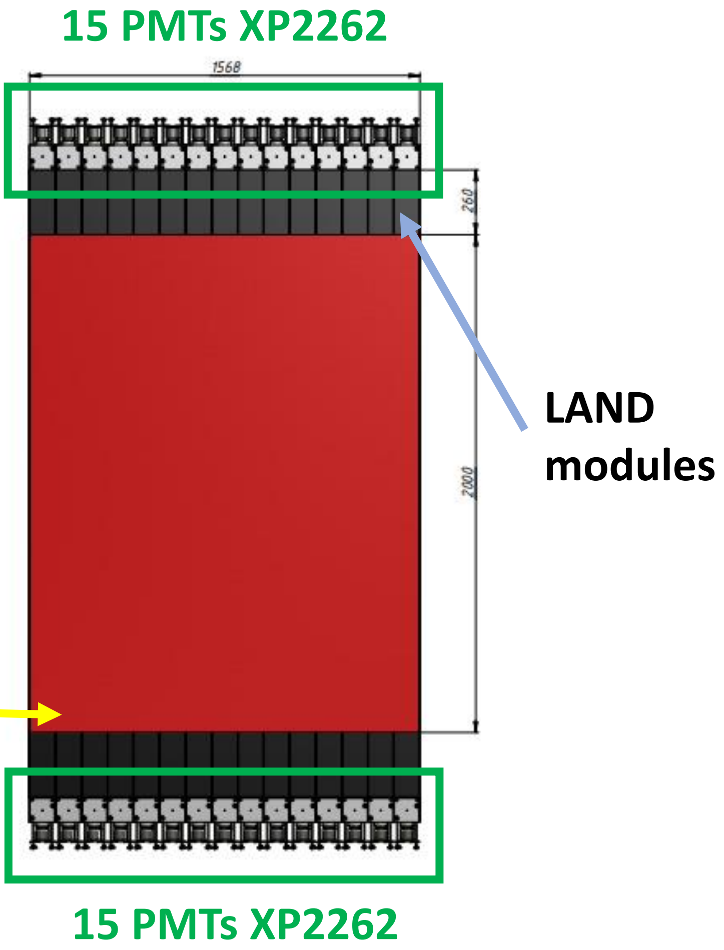


LAND module design

LAND modules:
alternating layers of iron and scintillator

Proton-pion calorimeter for SRC





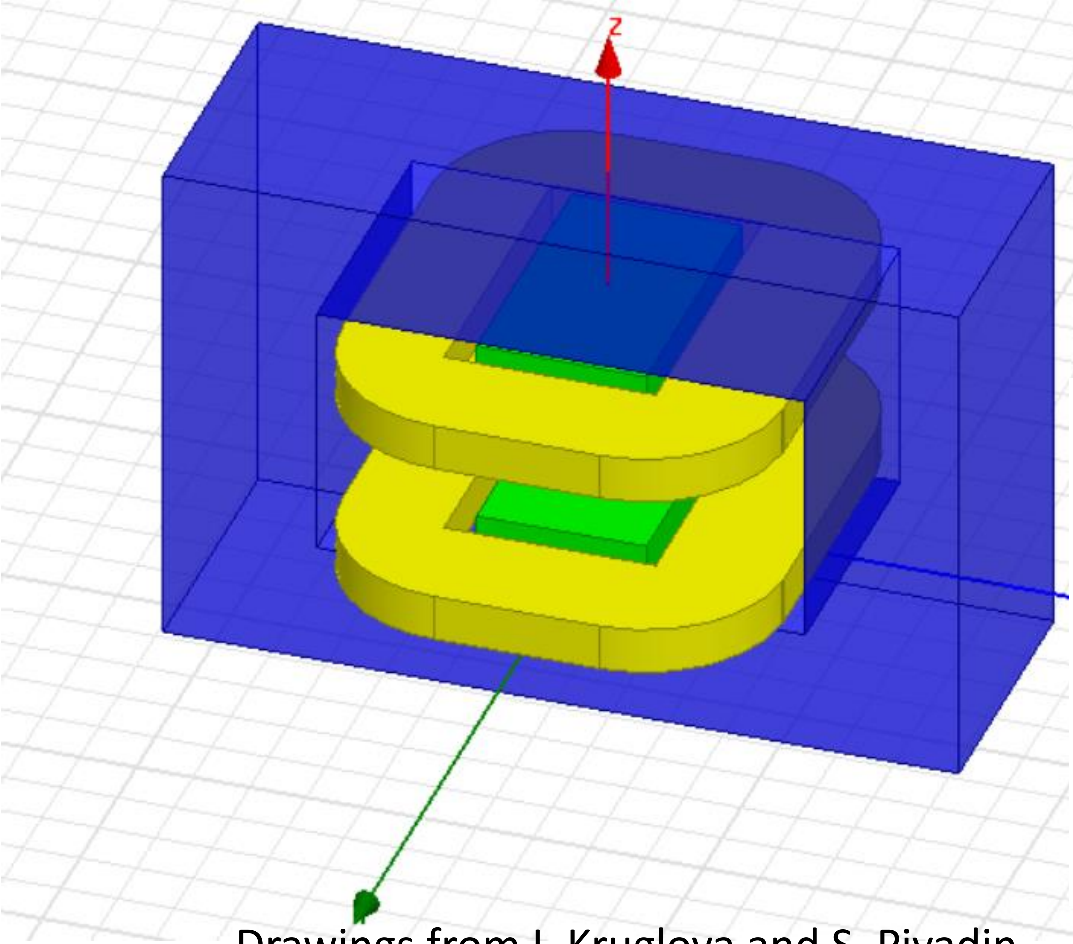
The PMTs XP2262 sensitive to the field ~1G

The detailed magnetic field measurement of SP-41 is planned for August 21

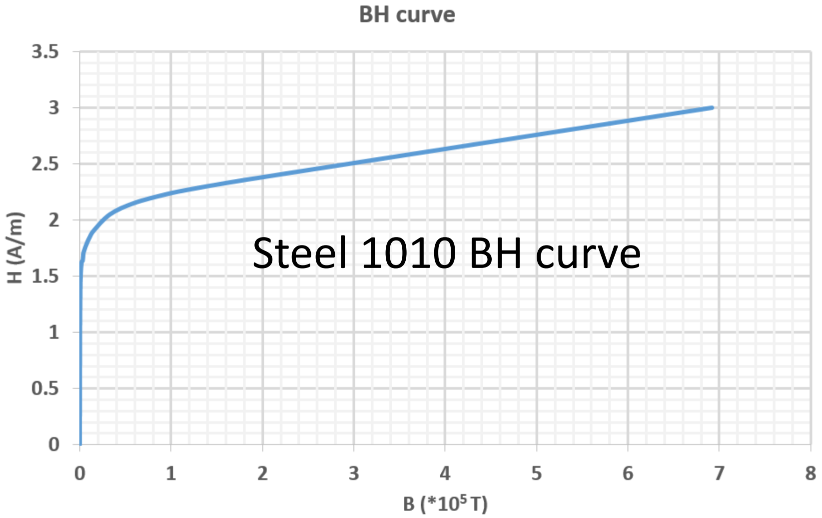
Field simulation is essential for developing a suitable shielding for PMTs

I. Kruglova
S. Piyadin

Field inside the SP-41 magnet. Input parameters.

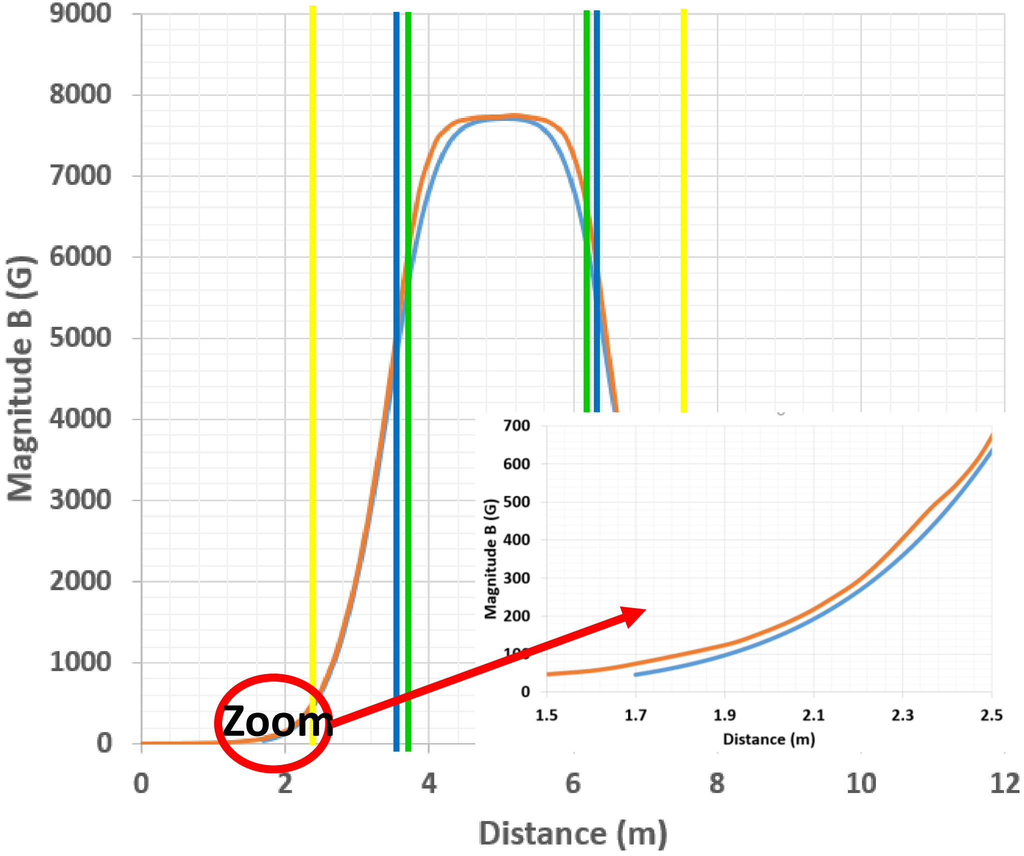


Program: Ansoft Maxwell
Solution type: Magnetostatic
Materials:
 Yoke & poles: steel 1010 (BH curve)
 Coils: copper
Current: assumed 200 turns x 1800 A



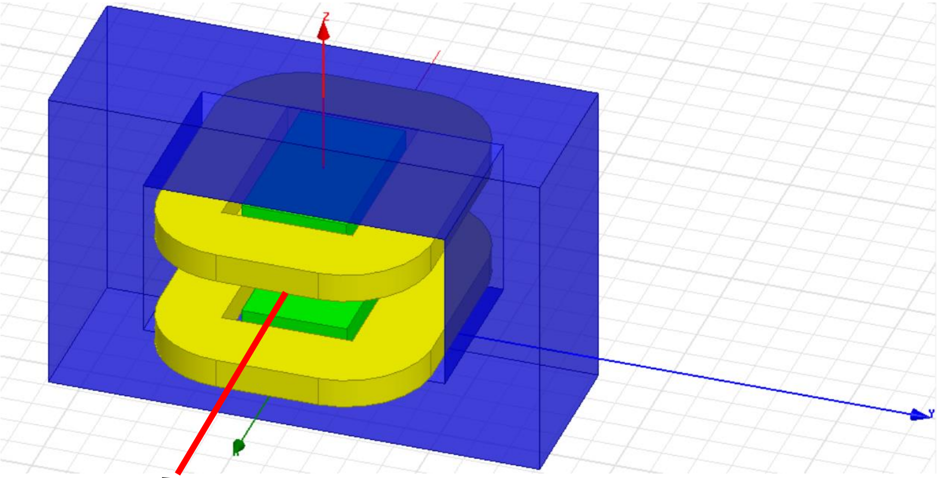
Drawings from I. Kruglova and S. Piyadin

Field inside the SP-41 magnet. Comparing to the field map



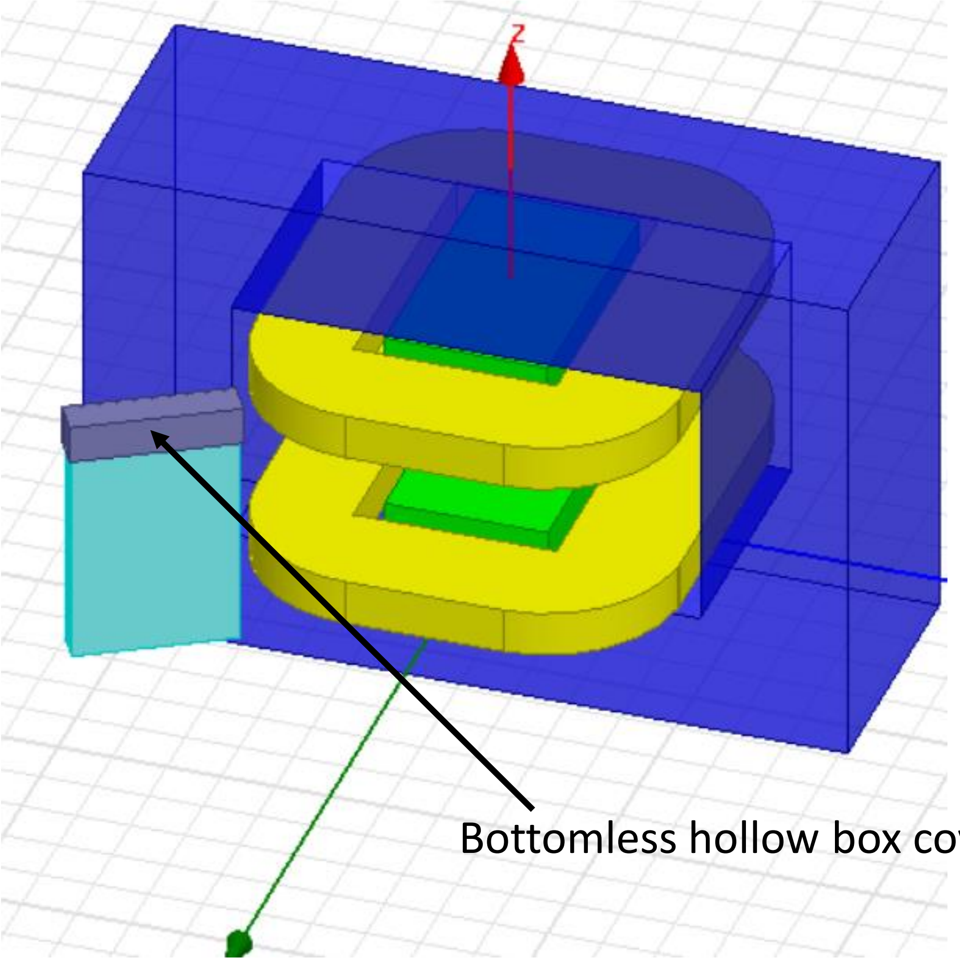
Measured data (blue line) were obtained in the limited area of the SP-41 magnet. Not including the region of the PMT.

B_{MaxM} = 1.15 * B_{MaxS}



Field is measured along the line

Field at the PMTs. Input parameters.



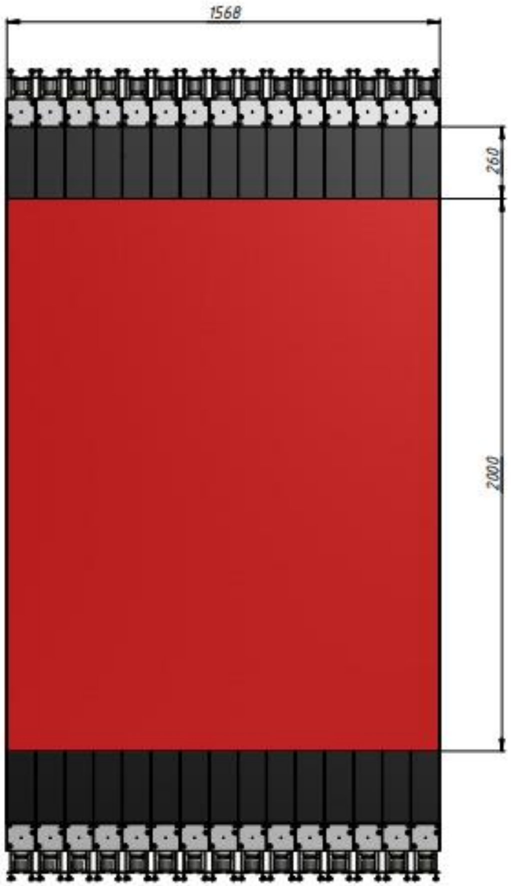
Program: Ansoft Maxwell
Solution type: Magnetostatic
Materials:
- Calorimeter sheets: iron (mu=10000)
- Yoke & poles: steel 1010 (BH curve)
- Coils: copper

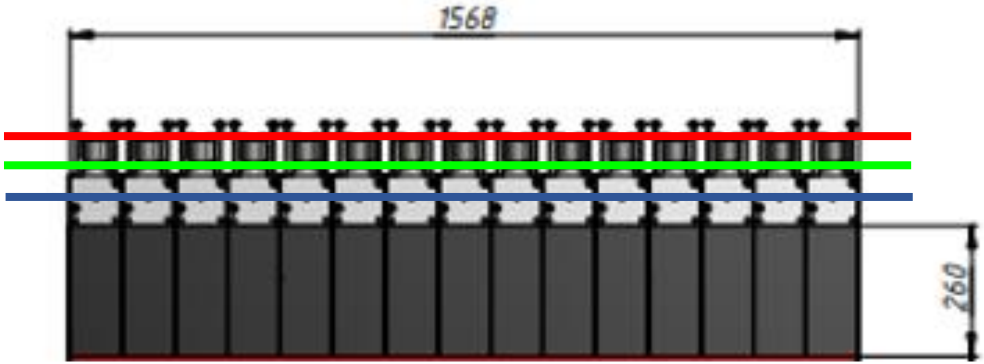
Current: assumed 200 turns x 1800 A

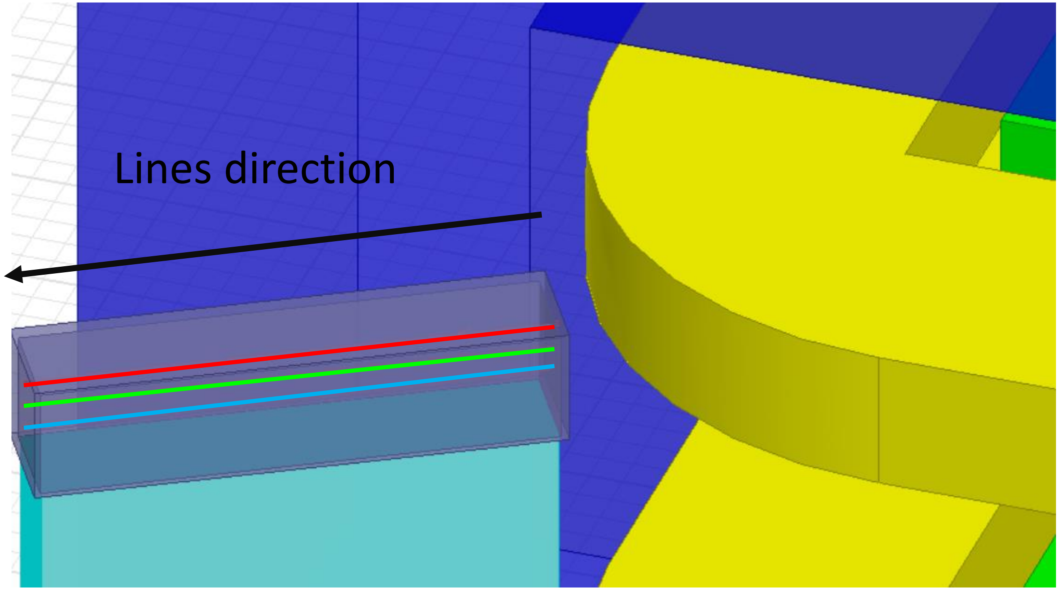
Bottomless hollow box covers PMTs of the calorimeter.

Field at the PMTs.

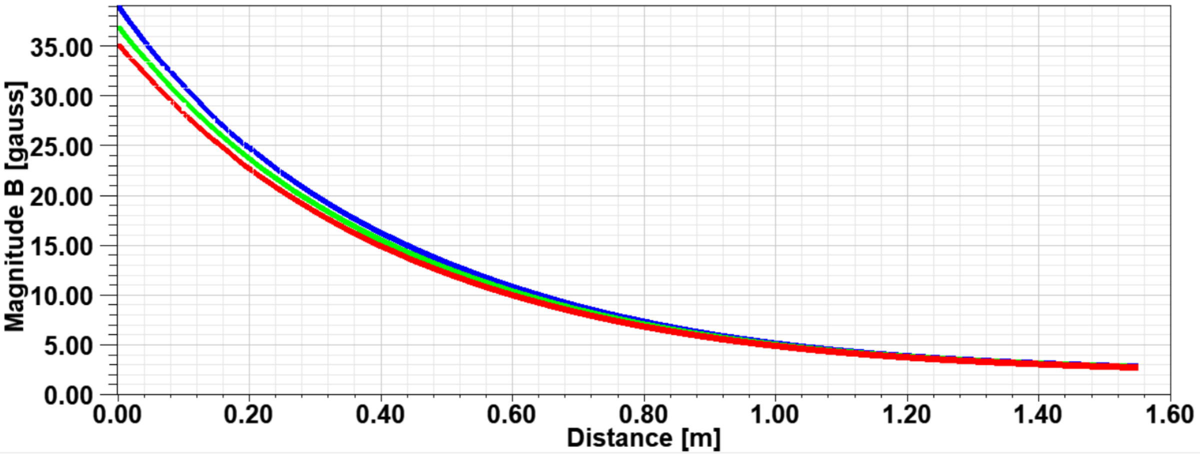
Field is measured along the line crossing the axis of each PMT near the top, middle and bottom of each PMT

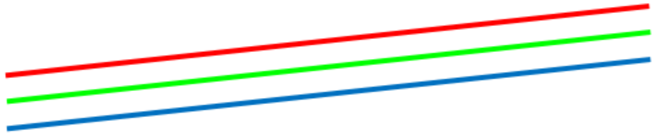




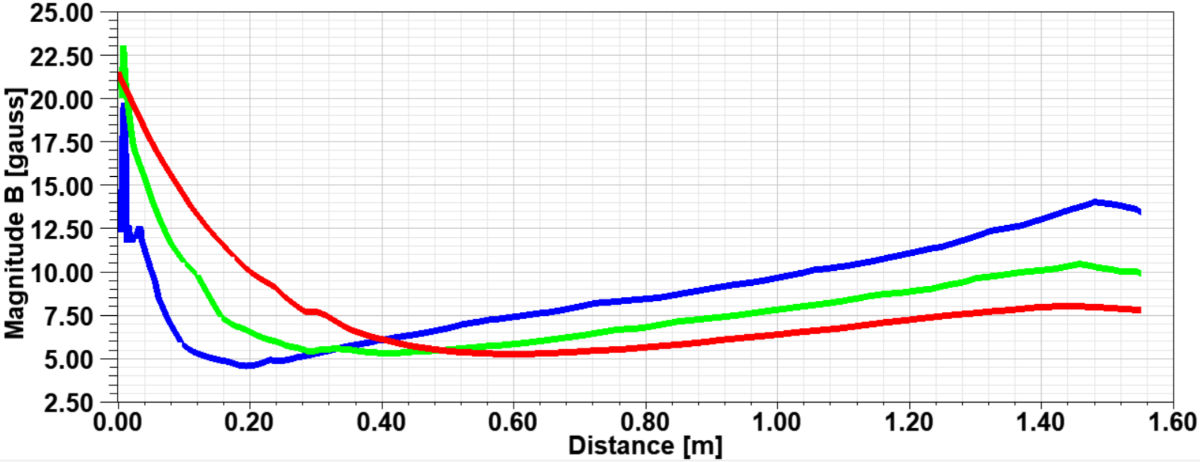


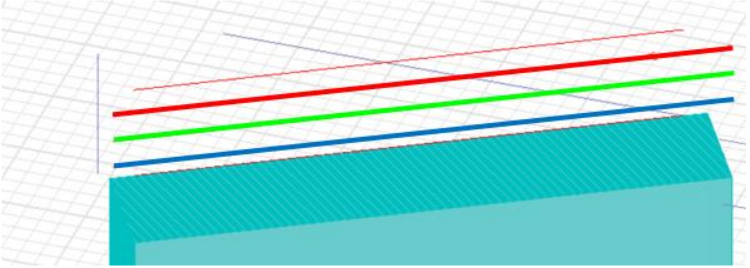
Field at the PMTs. The field in the PMTs region (no iron box)





Without LAND modules

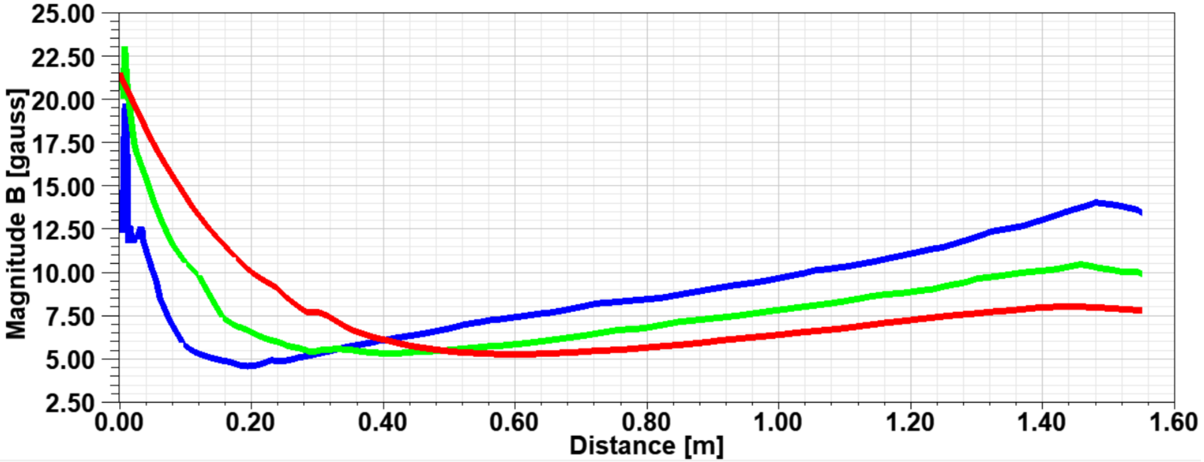


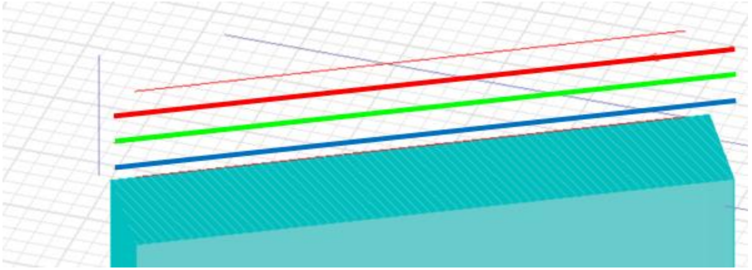


With LAND modules

Iron reduced the distance dependence of the magnetic field

Field at the PMTs. The field in the box
Bottomless hollow box covers PMTs of the calorimeter

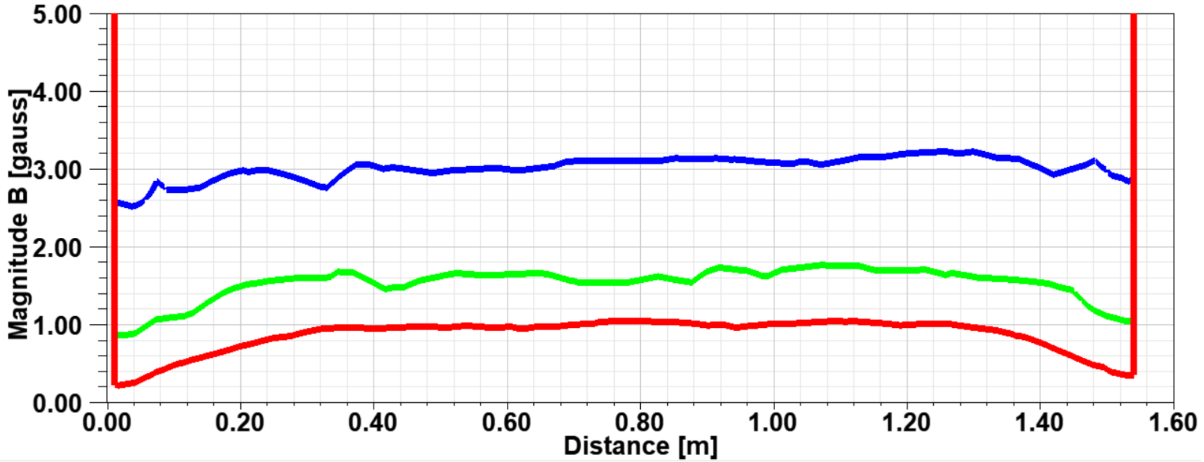


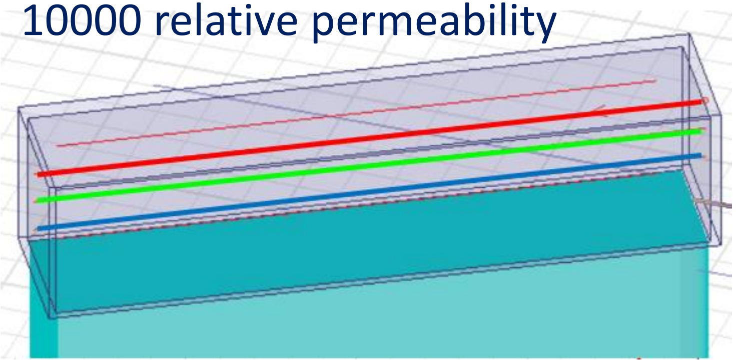


Without box

20 mm box thickness

10000 relative permeability



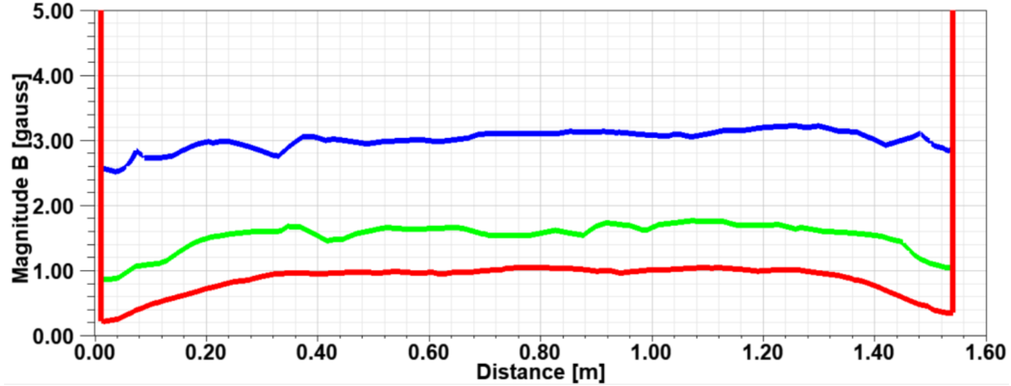


With box

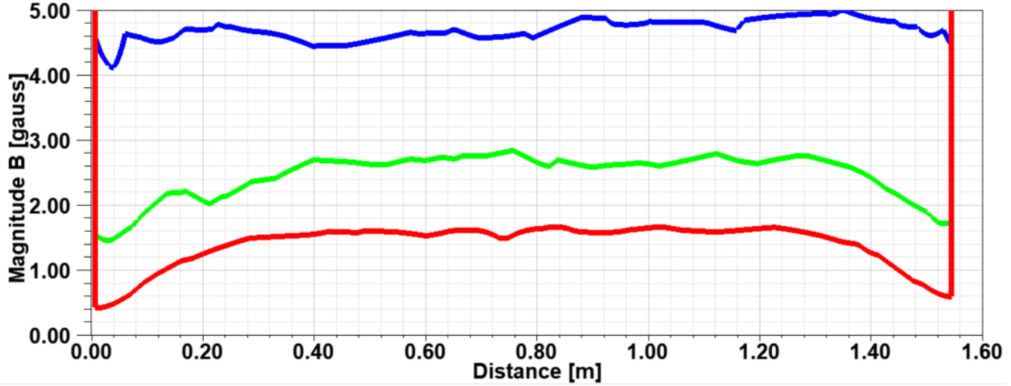
The field inside the box < 5 Gauss

Field at the PMTs. The box thickness

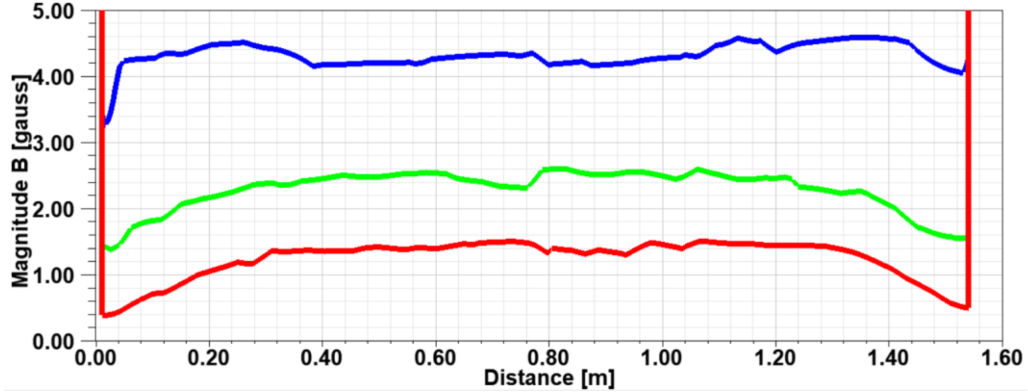
20 mm box thickness



5 mm box thickness



10 mm box thickness

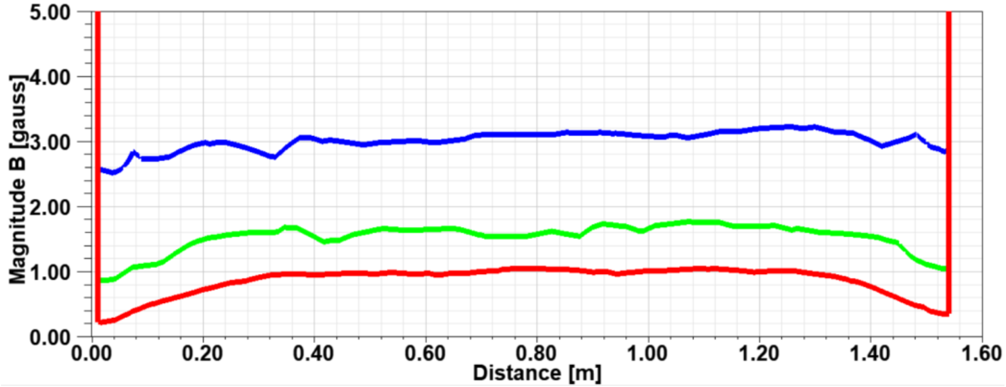


Thinner box —> higher field
Thinner box is easier to handle (lower mass)

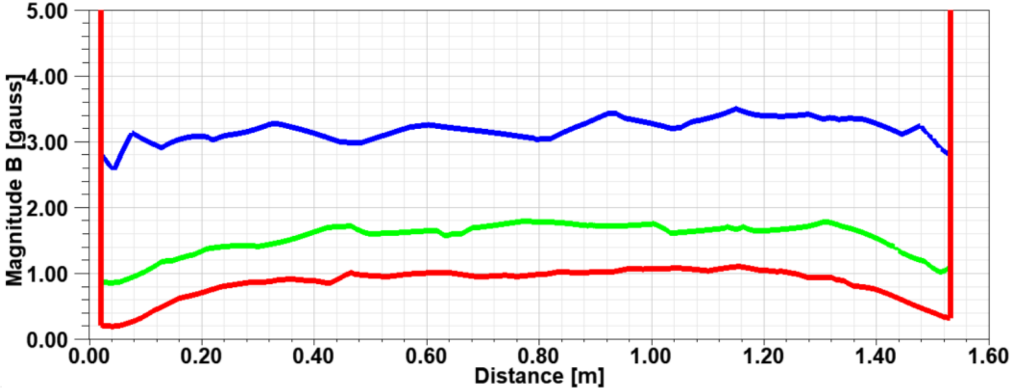
10 mm box was chosen

Field at the PMTs. The box material

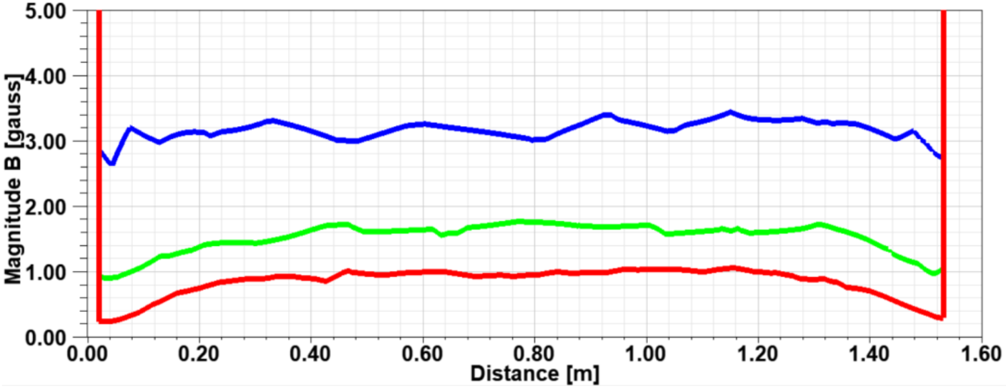
mu = 10 000



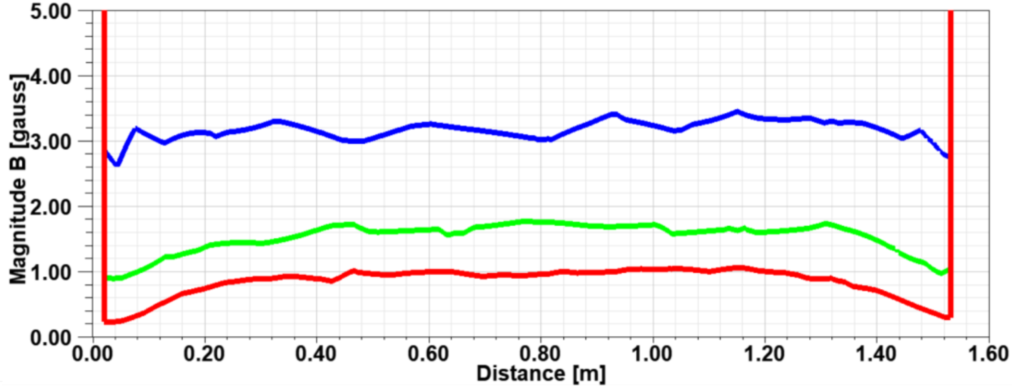
mu = 2500



mu = 5000



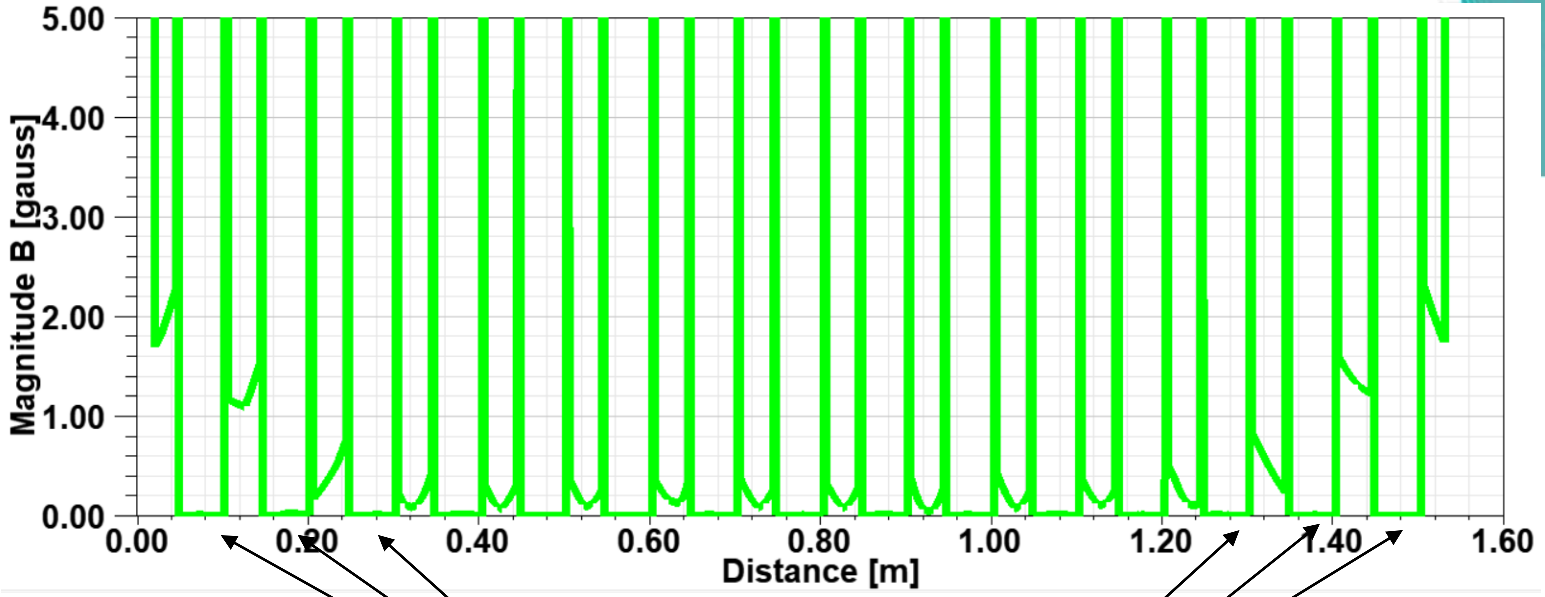
Steel1010 (BH curve)

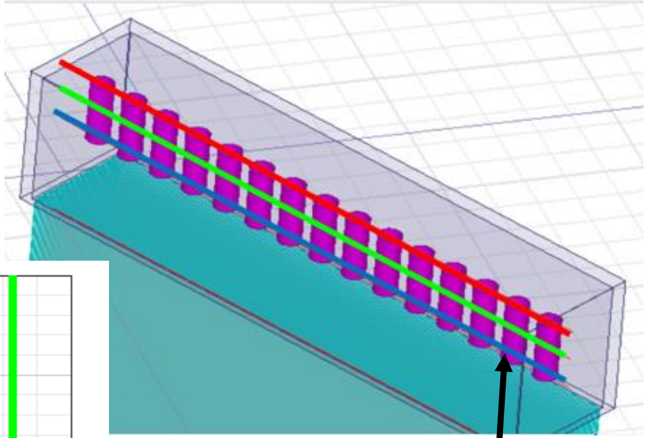


Relative permeability does not have a strong influence on the magnetic field inside the box.
Steel 10, steel 3, steel 7 or its analogs could be used.

Field at the PMTs. Box and mu metal shielding

LAND modules include mu-metal shielding around PMTs. So that mu-metal tube have been added to the simulation.





2 mm mu-metal tubes around PMTs

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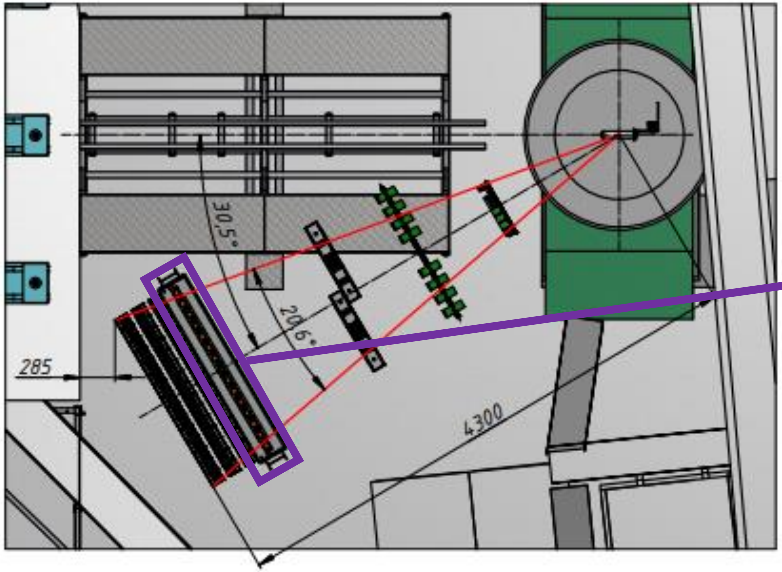
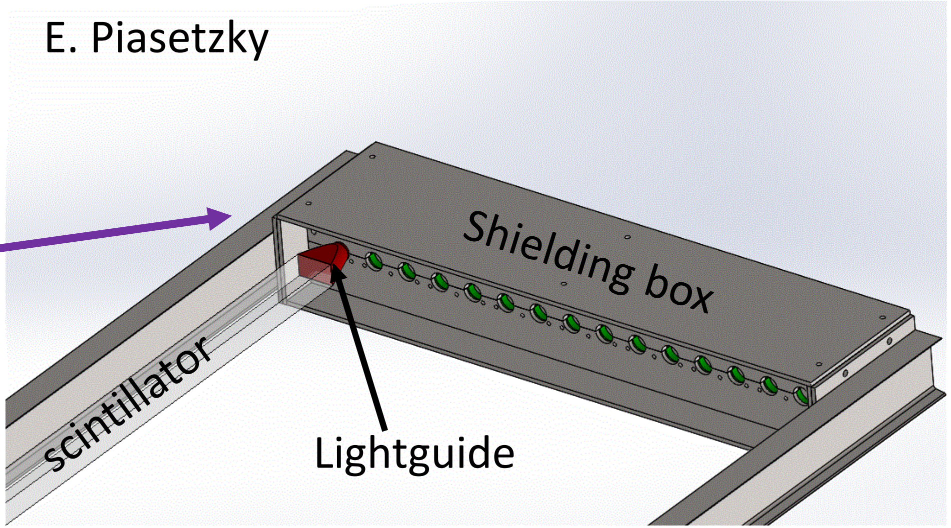
Inside box + mu-metal the field is less than 1 Gauss

Field at the PMTs. Box for TOF layer





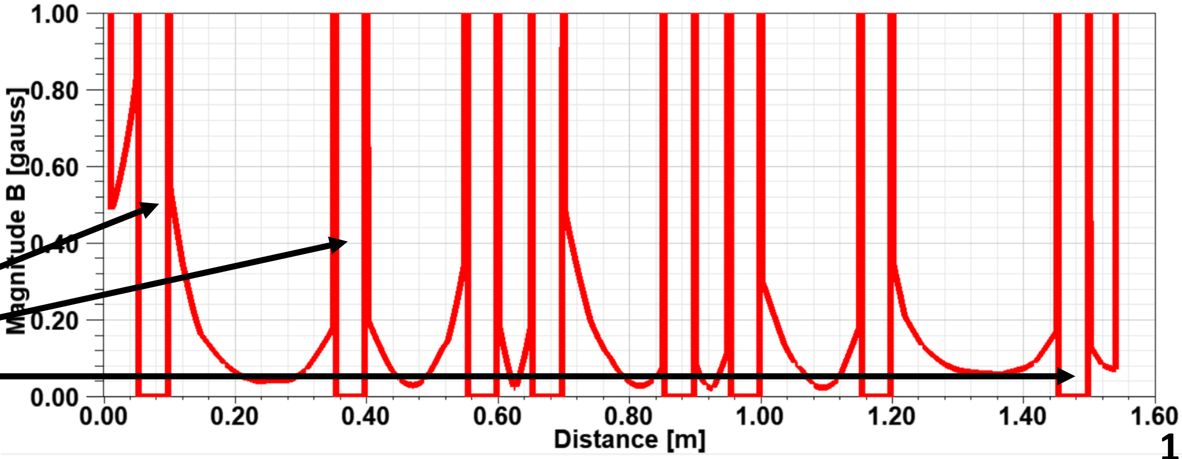
Simulation parameters

Box thickness: 10 mm

Box permeability: 10 000

Mu-tubes doesn't touch the box

Region inside the tubes



Conclusion

Simulation reproduce the magnetic field between the magnet poles.

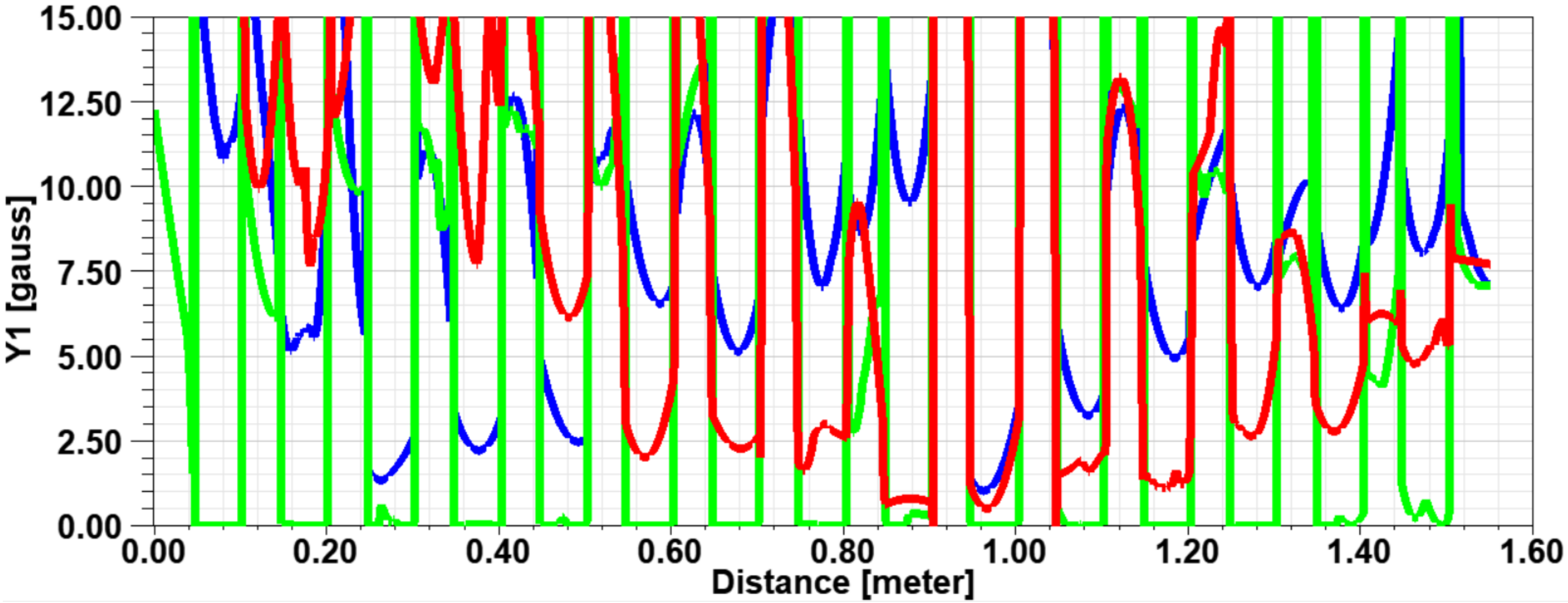
The simulation was used to extrapolate the field to the area of PMTs.

Optimized shielding parameters:

- iron box with 10mm walls
- individual mu-metal for each PMT

-> less than 1 Gauss field

Only mu



15.00
12.50
10.00
7.50
5.00
2.50
0.00
Y1 [gauss]
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
Distance [meter]