SQUID
Shielding Simulation

WP 4 meeting 2025/04/02
FLASH readout

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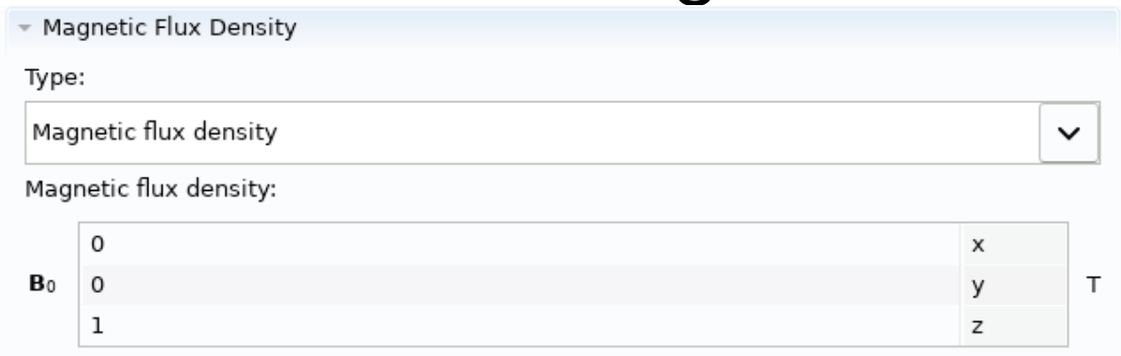
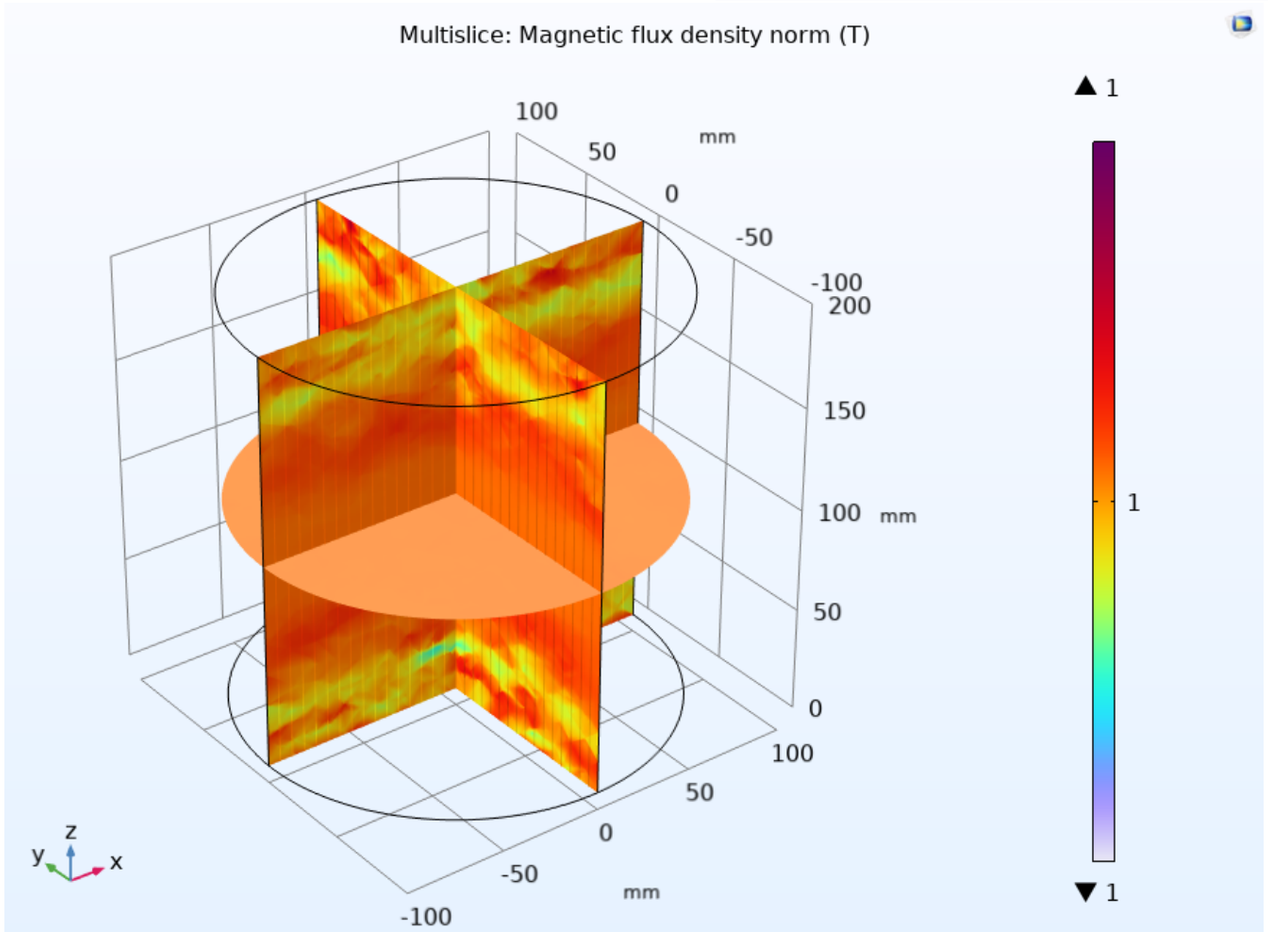
COMSOL

- Testing a simple cylinder of Air with a uniform magnetic field
  - 1 T at the boundary faces





From the KLASH TDR

A. Passive Magnetic Shield

The passive magnetic-shielding approach is realized with long tubes of high-permeability or superconducting material [159]. Magnetic-field lines are diverted around a volume of interest reducing the local magnetic-field in the region within the shielded volume. The analytical expression of the magnetic-field shielded by a 'semi-infinite' tube, both respect to axial and transverse (radial) directions, is given in [154] for SC tubes (see Fig. 6.8)

$$H_{\text{axial}} = H_{DC}\exp\left(-3.832\frac{z}{d}\right) \qquad H_{\text{transverse}} = H_{DC}\exp\left(-1.84\frac{z}{d}\right), \tag{6.1}$$

and for μ-metal tubes

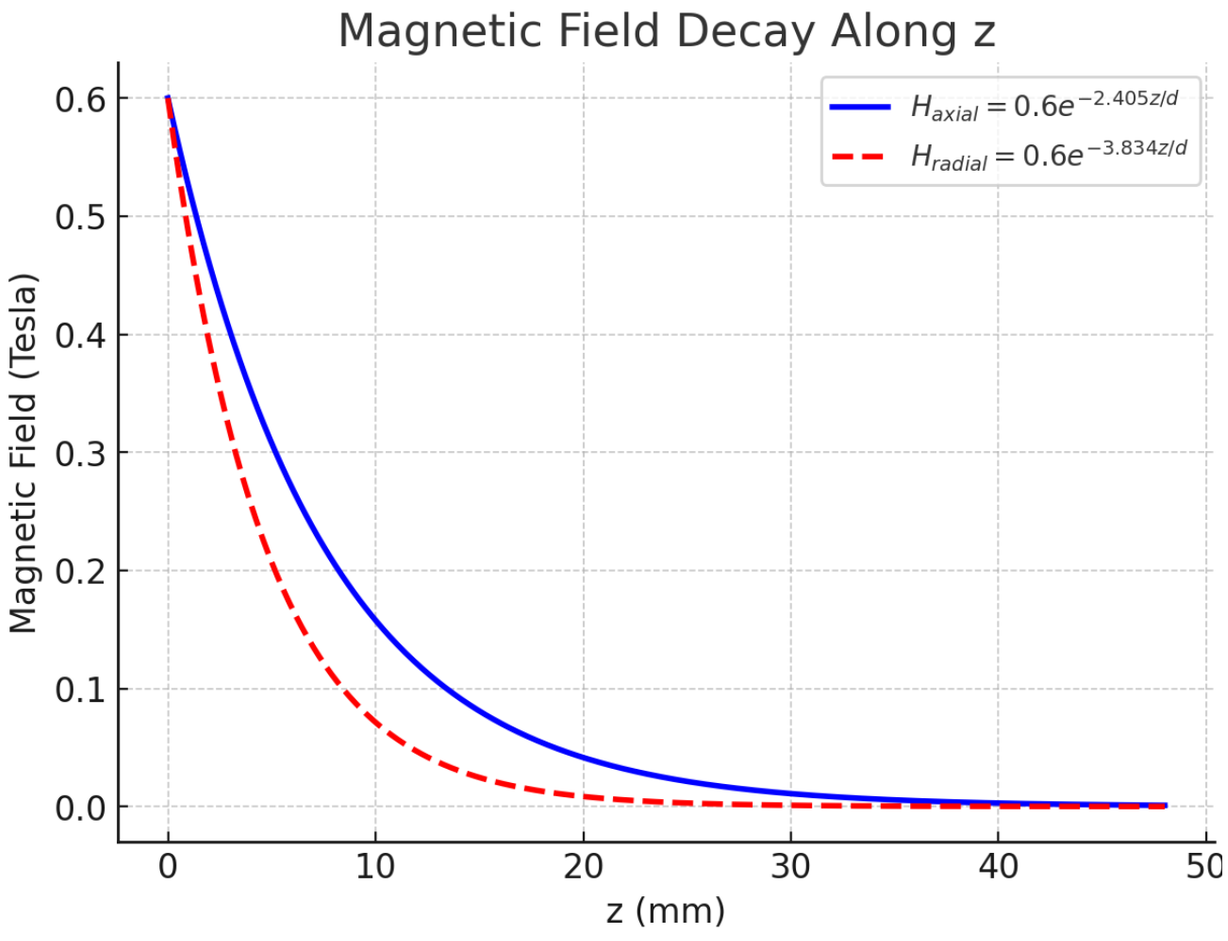
$$H_{\text{axial}} = H_{DC}\exp\left(-2.405\frac{z}{d}\right) \qquad H_{DC-\text{transverse}} = \exp\left(-3.834,\frac{z}{d}\right). \tag{6.2}$$

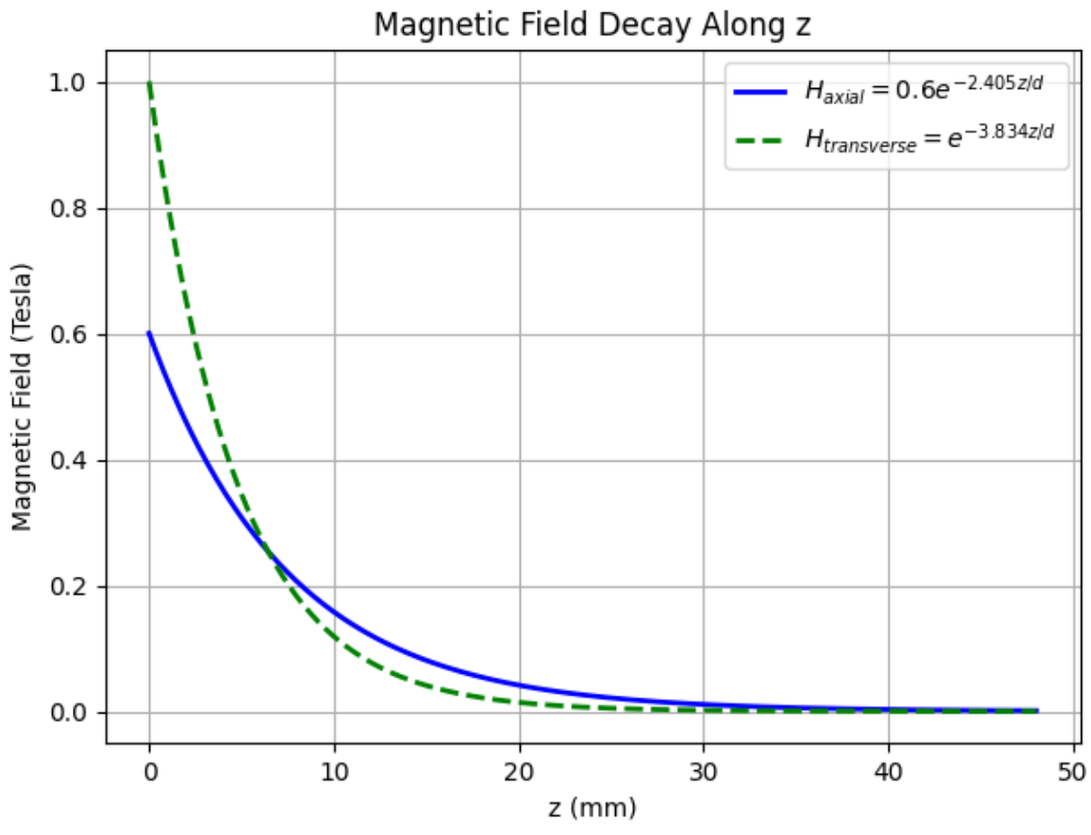
SC and μ-metal tubes are more effective in dumping axial and transverse fields, respectively.

Figure 6.8: Semi-infinite tube of radius d. The z-axis originates on the tube entrance and is oriented downward [154].

Magnetic field

- From KLASH TDR, shapes of magnetic field



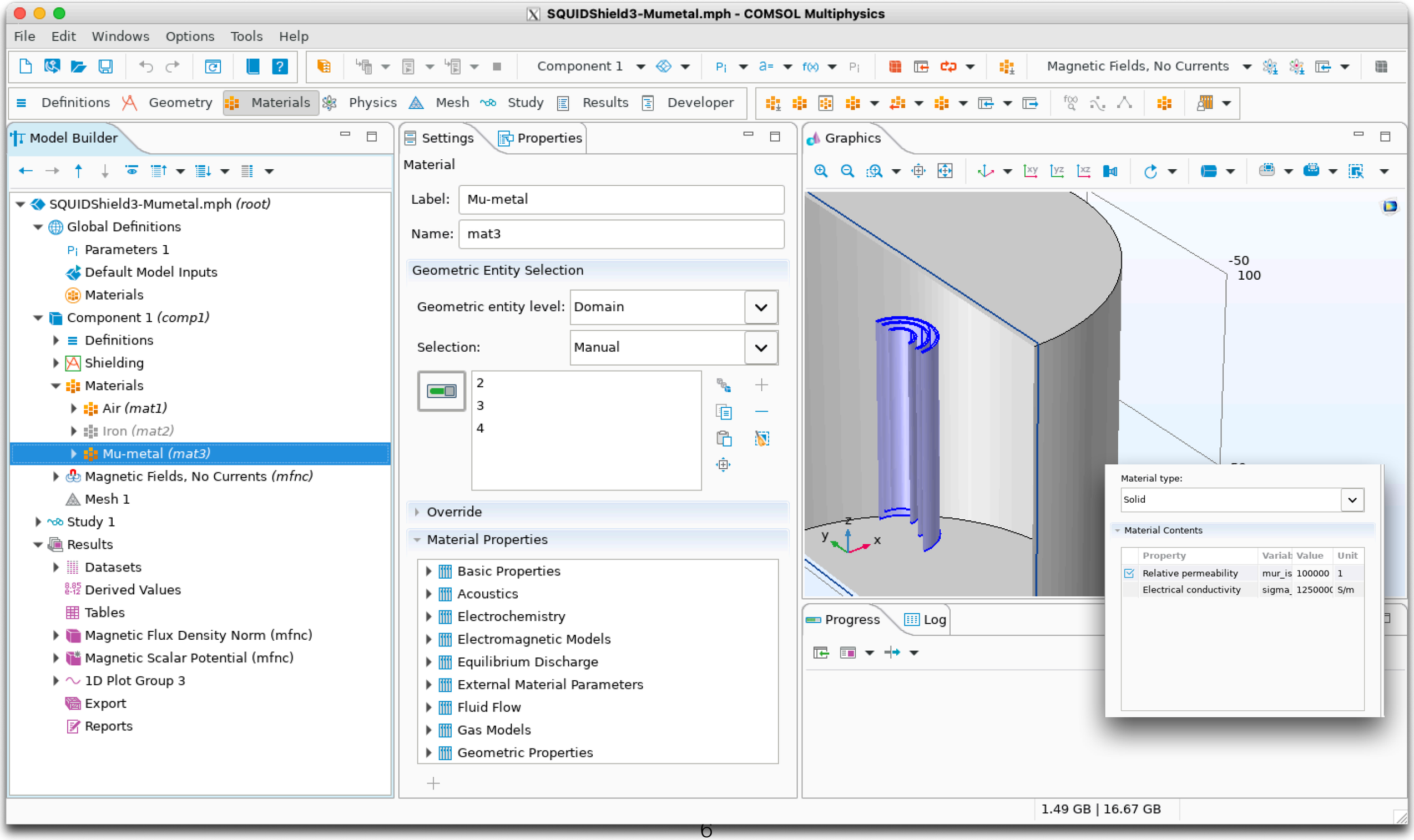


COMSOL simulation

- World => Cylindrical shape [h: 100 *mm*, r: 50 *mm*]; Air
- Magnetic fiel => Flux of 1 *T* at the boundaries (Top and Bottom faces)
- Three shielding cylinders:
  - Outer cylinder [h: 53 *mm*, r: 9 *mm*]; Mu-metal
  - Middle cylinder [h: 50 *mm*, r: 7 *mm*]; Mu-metal
  - Inner cylinder [h: 48 *mm*, r: 4 *mm*]; Mu-metal

    Thickness of 0.5 *mm*

Mu-metal


SQUIDShield3-Mumetal.mph - COMSOL Multiphysics
File Edit Windows Options Tools Help
Component 1
Magnetic Fields, No Currents
Definitions Geometry Materials Physics Mesh Study Results Developer
Model Builder
SQUIDShield3-Mumetal.mph (root)
Global Definitions
Parameters 1
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Component 1 (comp1)
Definitions
Shielding
Materials
Air (mat1)
Iron (mat2)
Mu-metal (mat3)
Magnetic Fields, No Currents (mfnc)
Mesh 1
Study 1
Results
Datasets
Derived Values
Tables
Magnetic Flux Density Norm (mfnc)
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1D Plot Group 3
Export
Reports
Settings
Properties
Material
Label: Mu-metal
Name: mat3
Geometric Entity Selection
Geometric entity level: Domain
Selection: Manual
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3
4
Override
Material Properties
Basic Properties
Acoustics
Electrochemistry
Electromagnetic Models
Equilibrium Discharge
External Material Parameters
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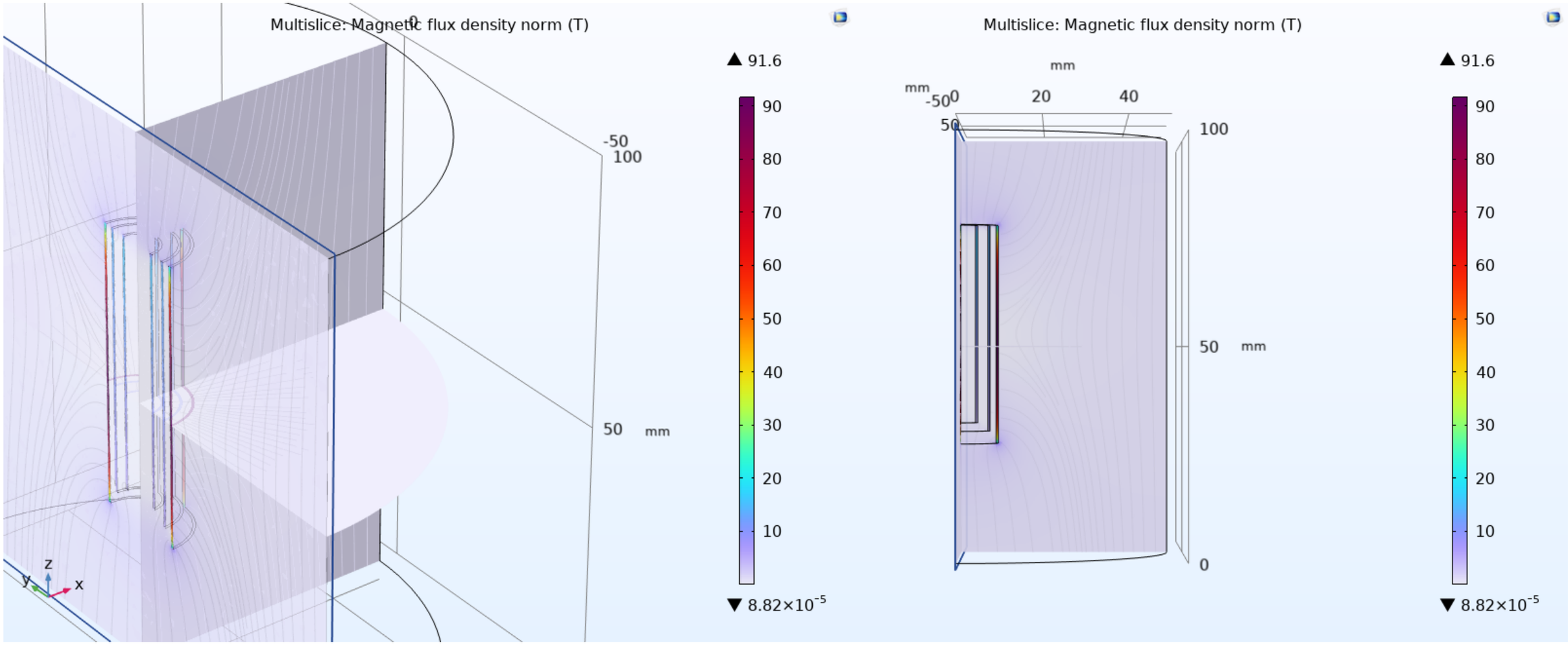
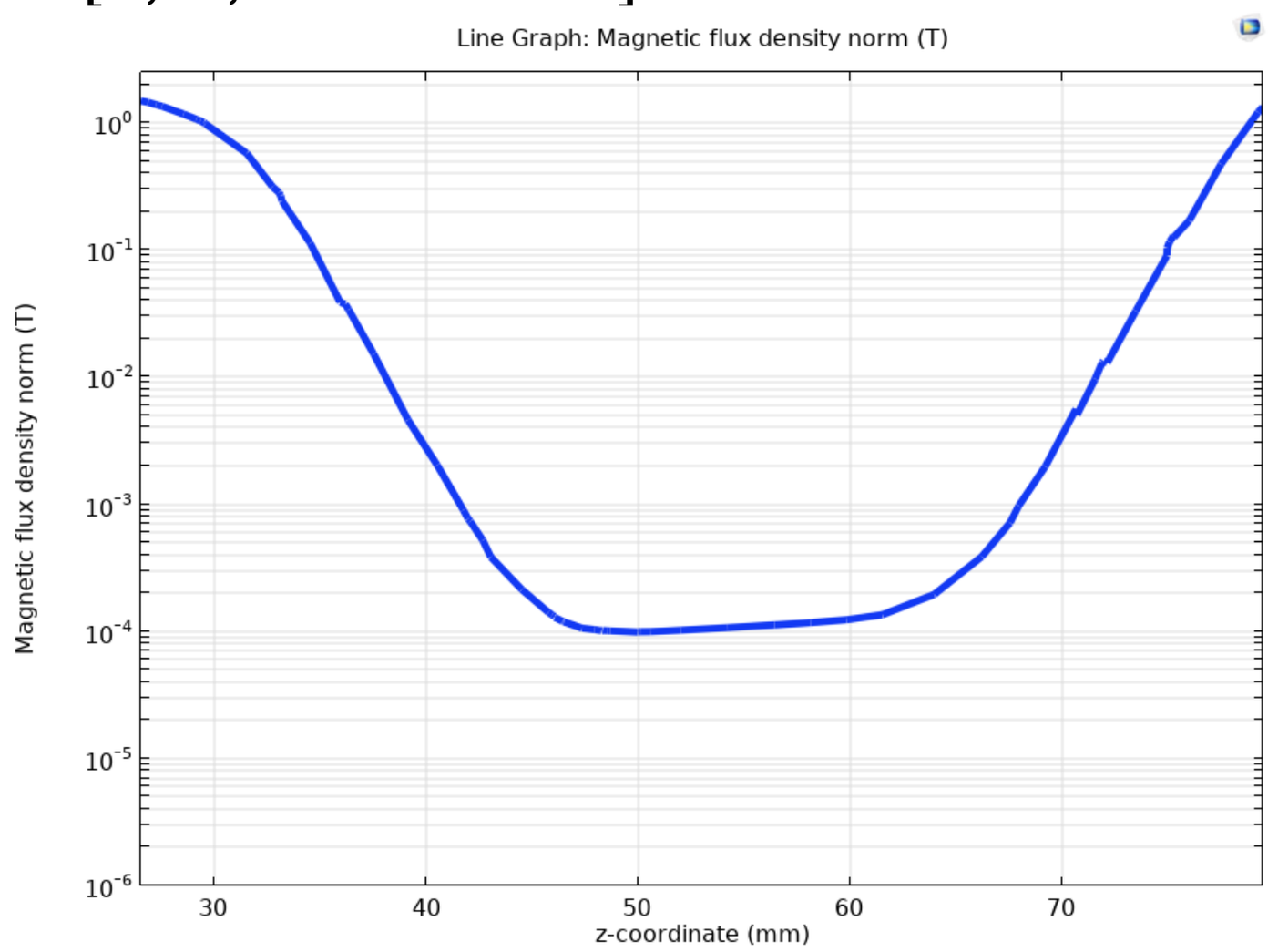
Visualising the B flux



- Shielding cylinders aligned to the same top edge (as in the KLASH TDR)

B field intensity

- Variation of the intensity as a function of z (internal to the triple shielding)
- Cut line at [0, 0, 26.5 - 79.5] *mm*

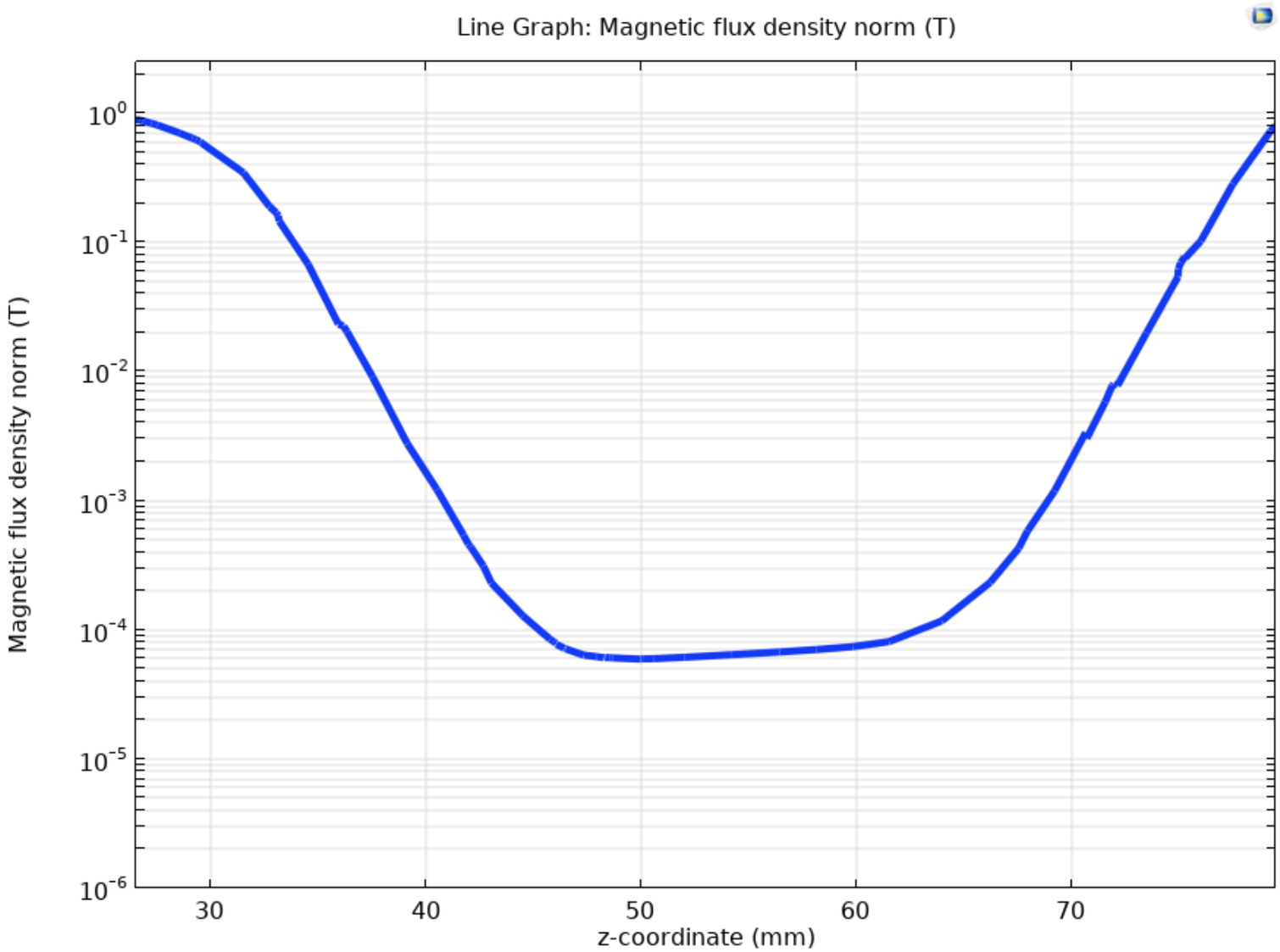


Status

- Not totally clear the distribution of H_{axial} and $H_{transverse}$
  - Uniform flux of 1 *T* at the two opposite faces of “World”
- Mu-metal:
  rel. perm.: 100000; el. cond.: 1250000 *S/m*
- Still not completely mastering COMSOL…
  - Insulation for the shielding? (not big changes)
- Reduction of the *B* field of only 10^{-4}…

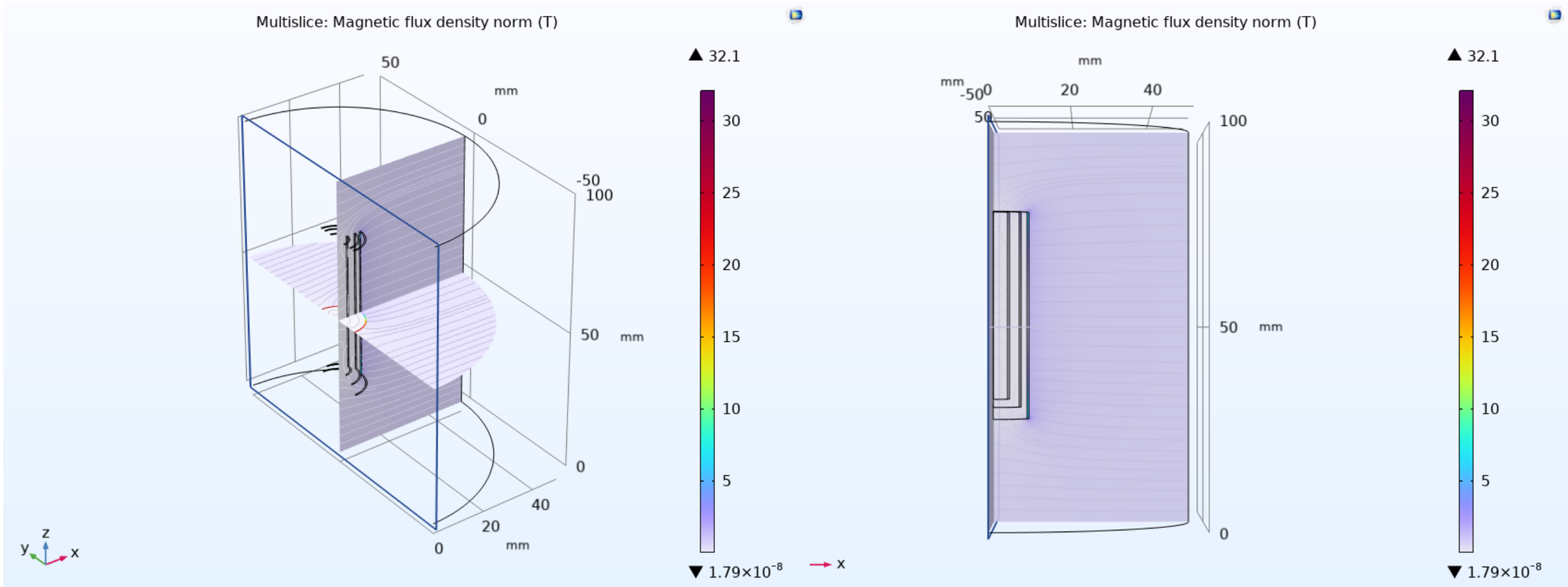
B field intensity

- Using 0.6 *T* at the world's faces



B oriented towards x

- Flux set to be equal to 0.6 T on the x axis



B oriented towards x