B0 Magnet Options

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Overview

- Preliminary designs for three options
  - Septum design
  - Halbach shielding
  - Superconducting compensation coil
- No option is perfect
- Tradeoffs
  - Performance: Fixed field, field quality
  - Cost
  - Size/weight

Septum Design

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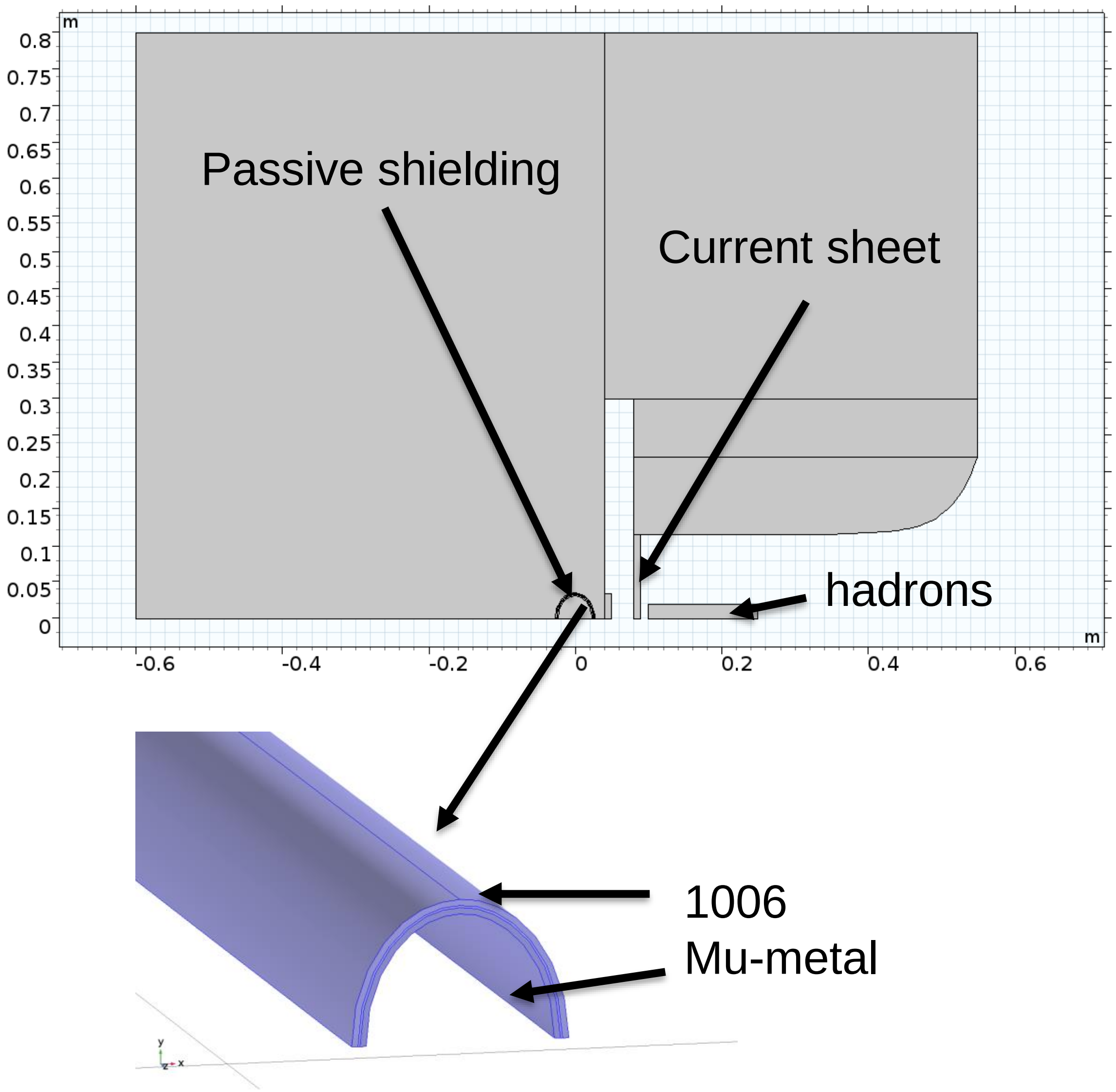
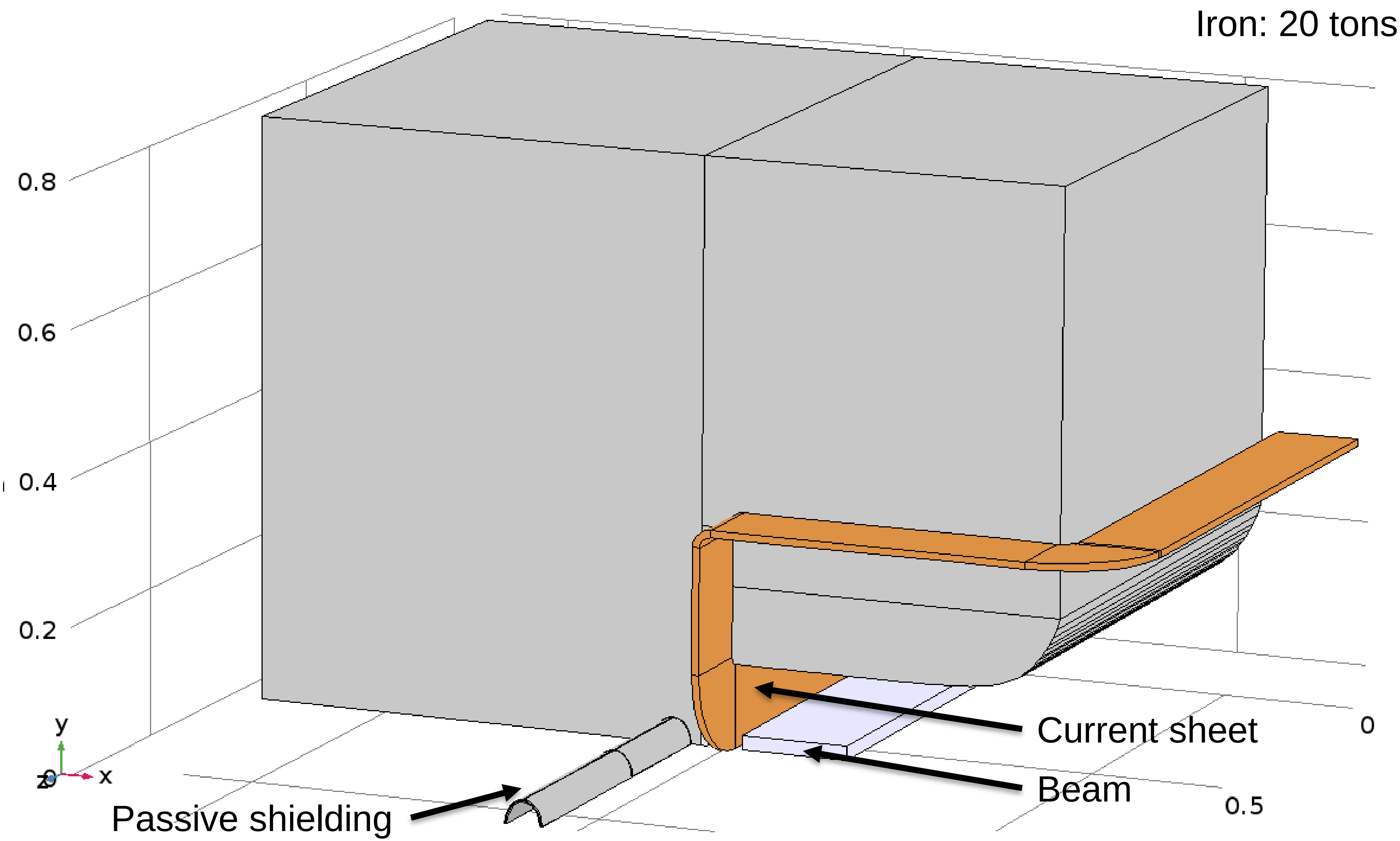
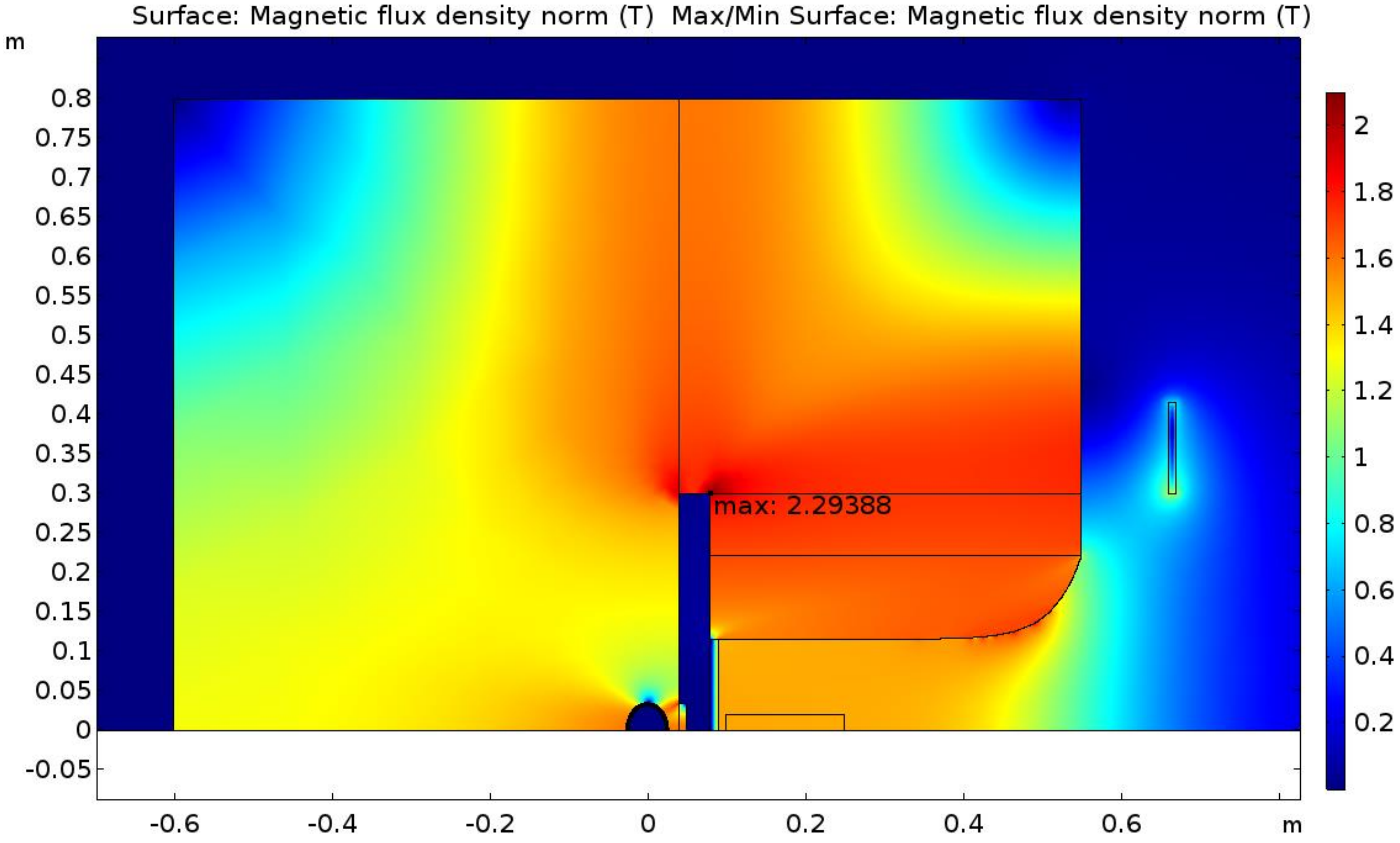


- Current sheet
- Passive shielding for electrons
- Pros
  - Good field quality for hadrons
  - Shielding passive
  - Cheap
- Cons
  - ‘blind’ beyond septum
  - Large
  - heavy

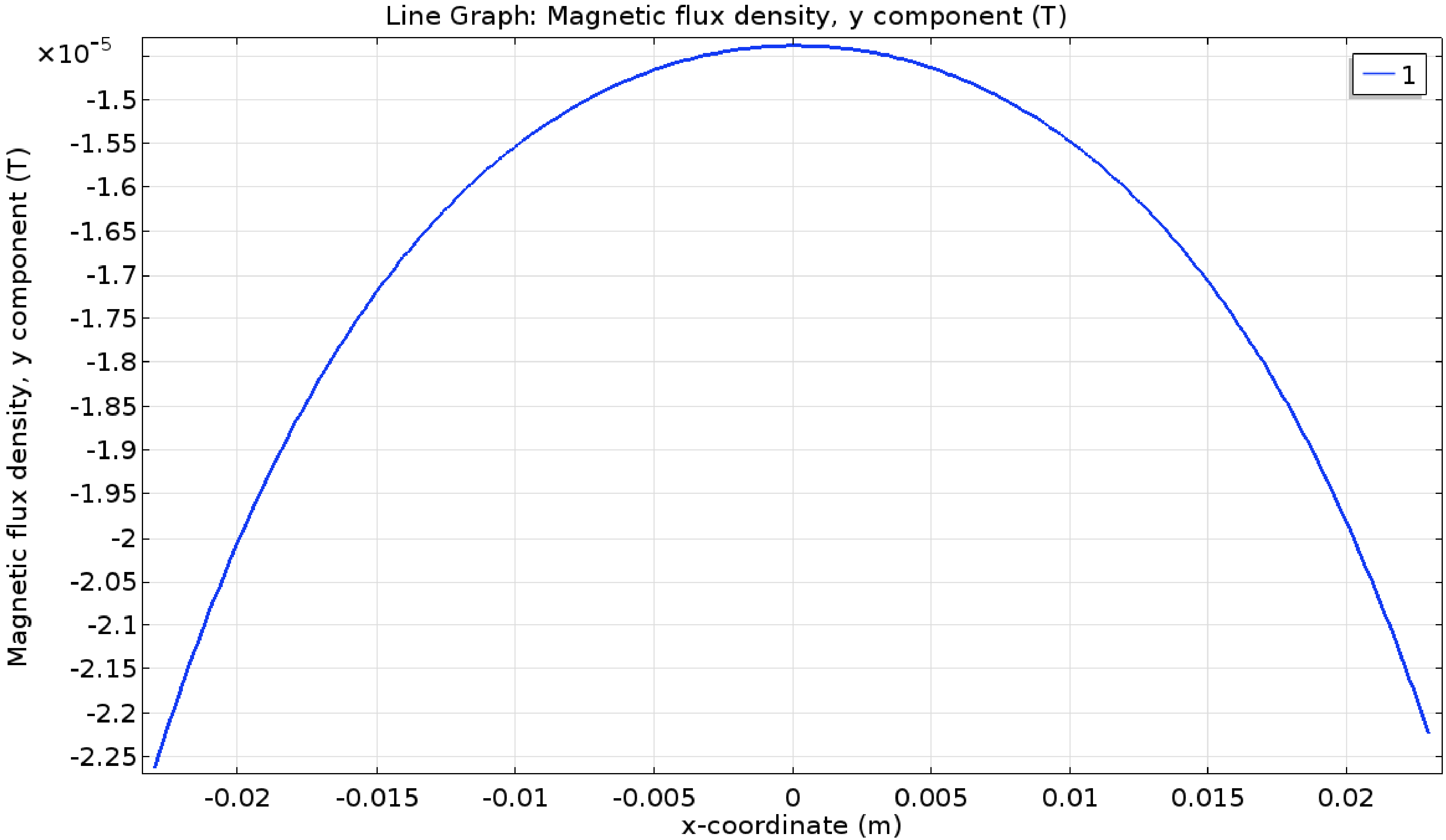
B0 Magnet


Iron: 20 tons
0.8
0.6
0.4
0.2
0
0.5
y
x
z
Current sheet
Beam
Passive shielding

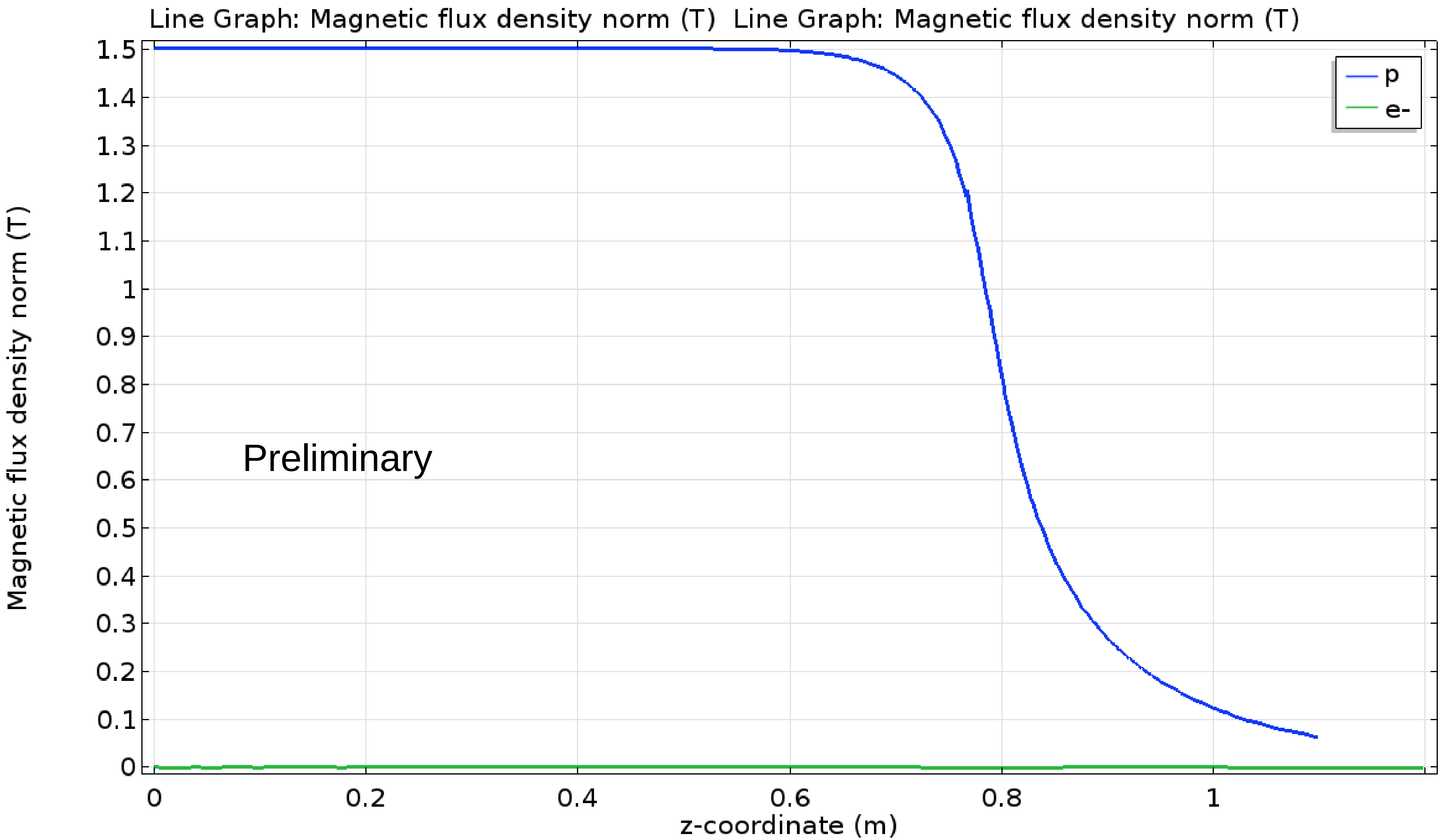
Magnetization



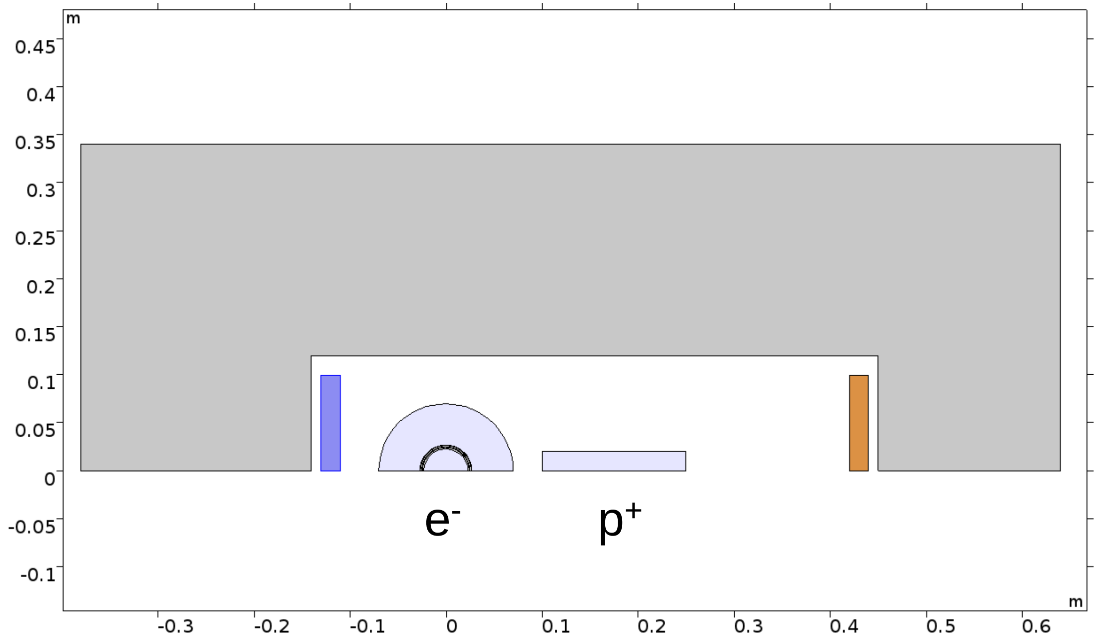
2D Field Shielded Region

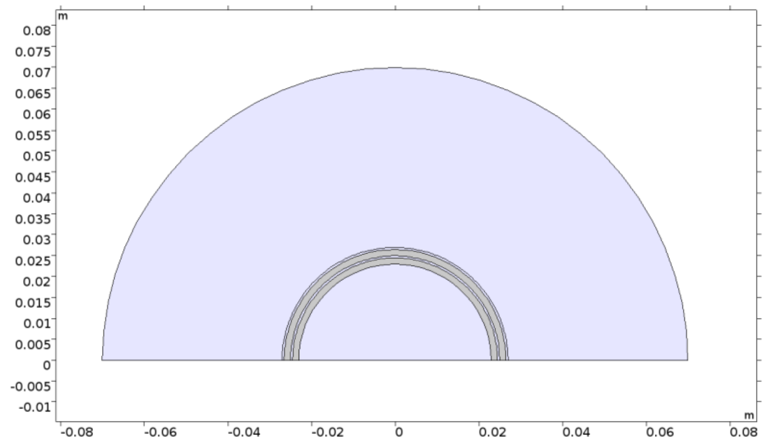


3D Field Shielded Region (Comparison)



B0 Spectrometer
Halbach Solution





- Compensation field provided by Halbach magnet
  - Needs to be at 77K for best performance
  - Passive shield for residual field
- Pros
  - Can be smaller than SC solution
  - Compensation field does not perturb field for protons
  - Additional space for detectors
  - Less expensive than SC solution
  - Smaller/lighter than septum design
- Cons
  - Fixed field

Geometry

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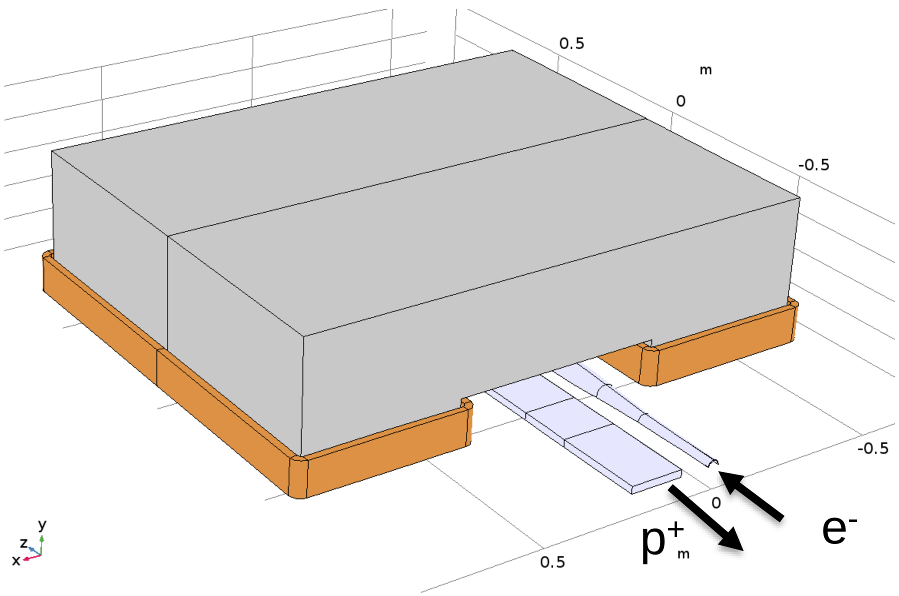
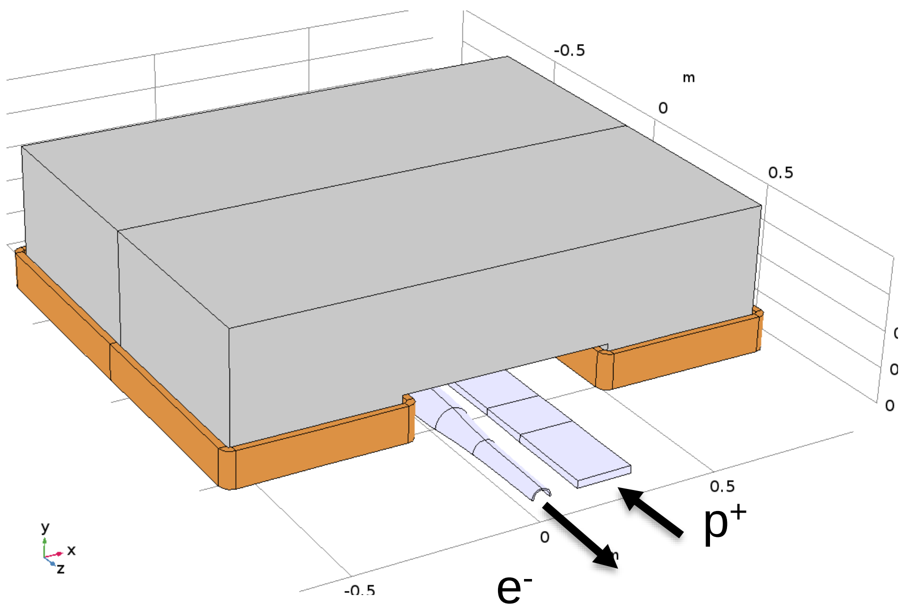
Front

Rear

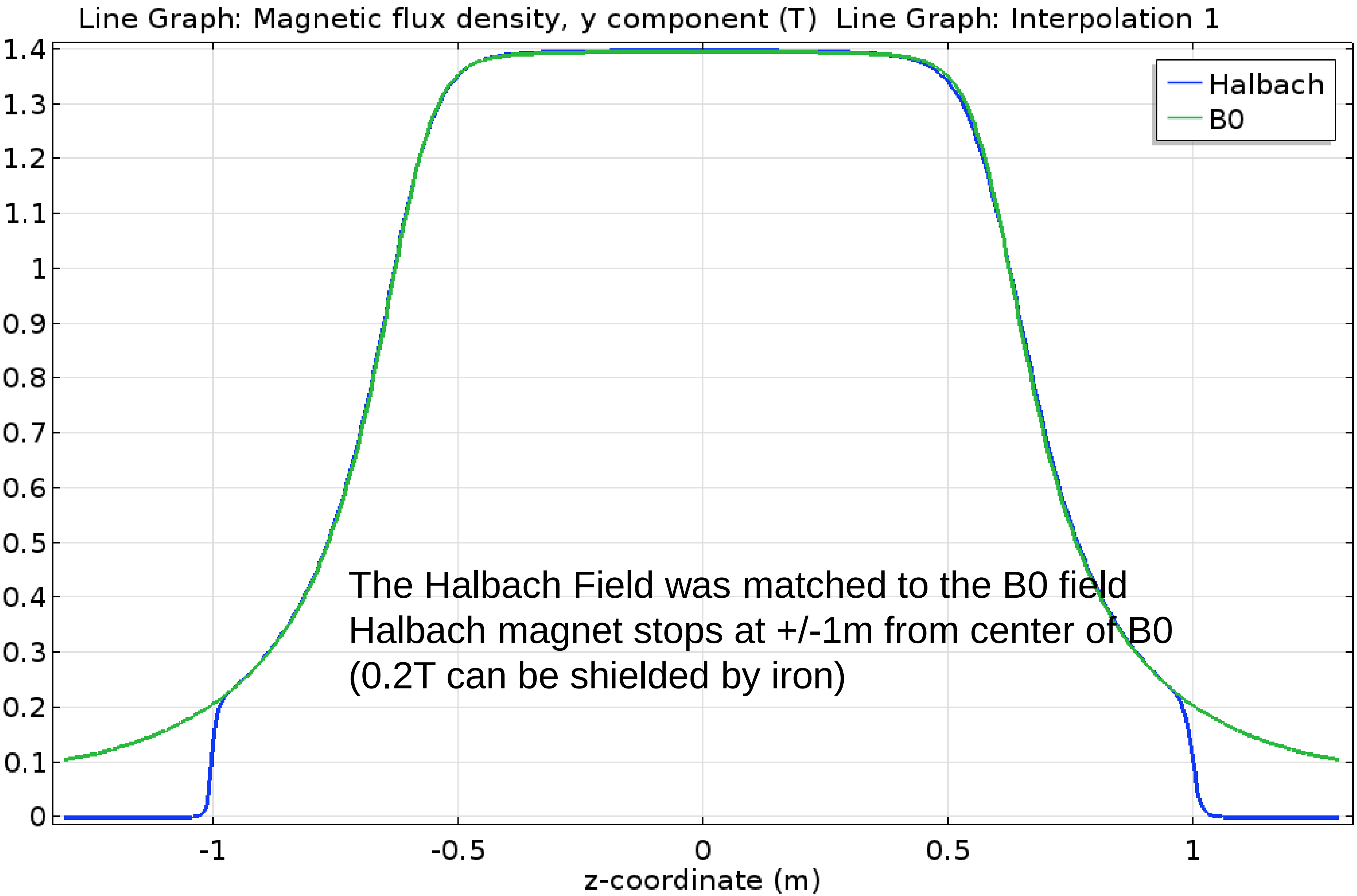




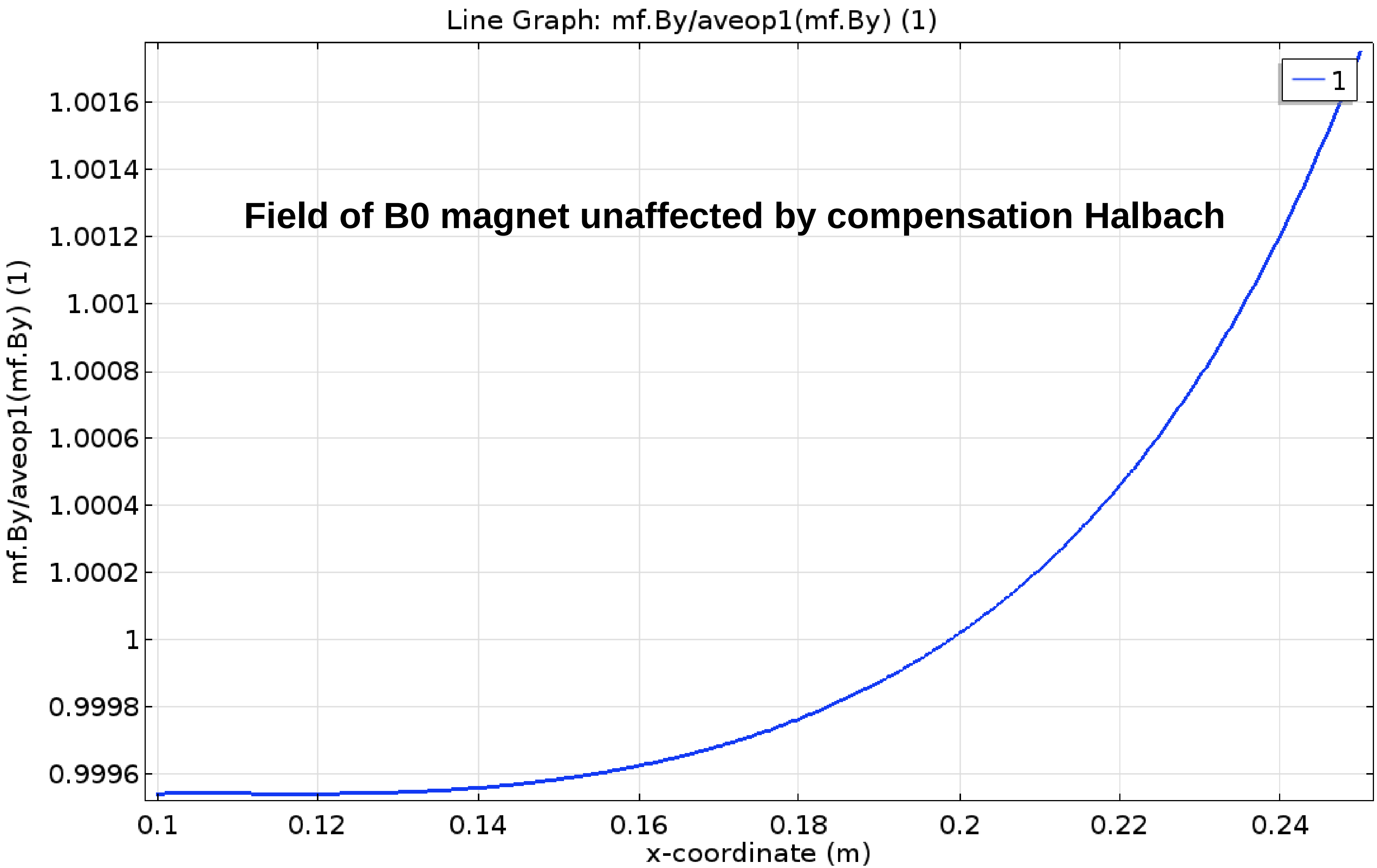
Hadrons: 1.4T
Electrons: 0T

Note: Coils will change

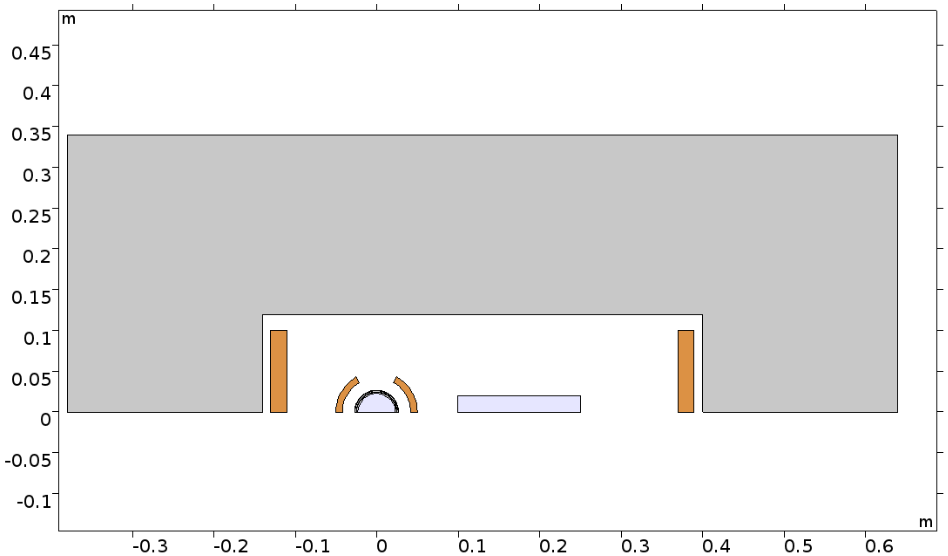
Halbach Field

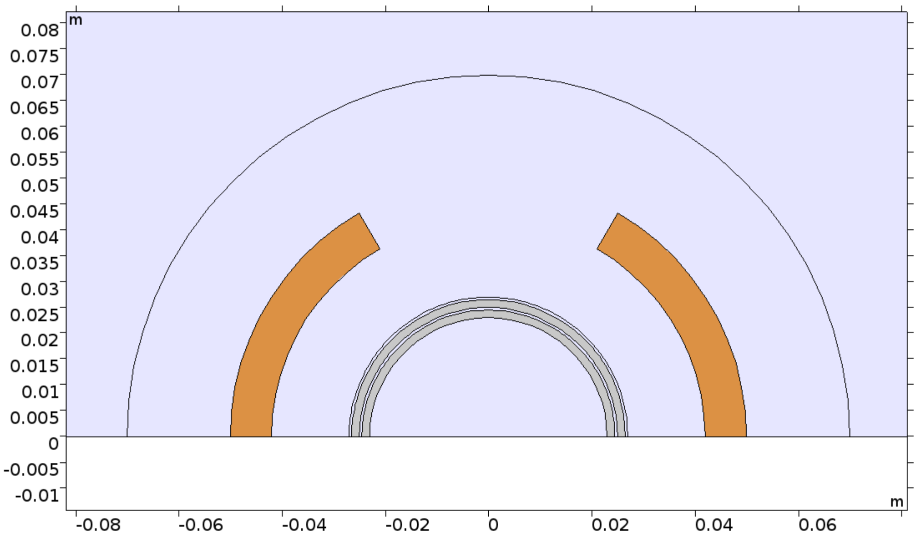


Field Quality Hadrons



Active Compensation Coil

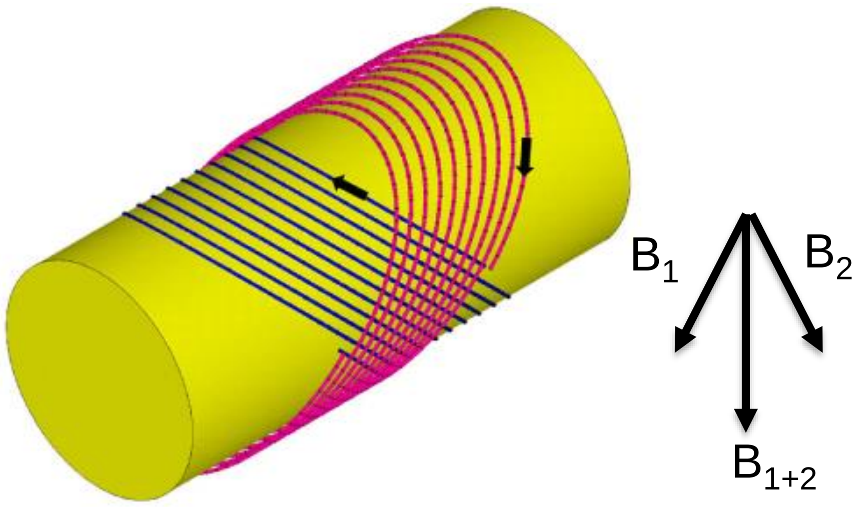


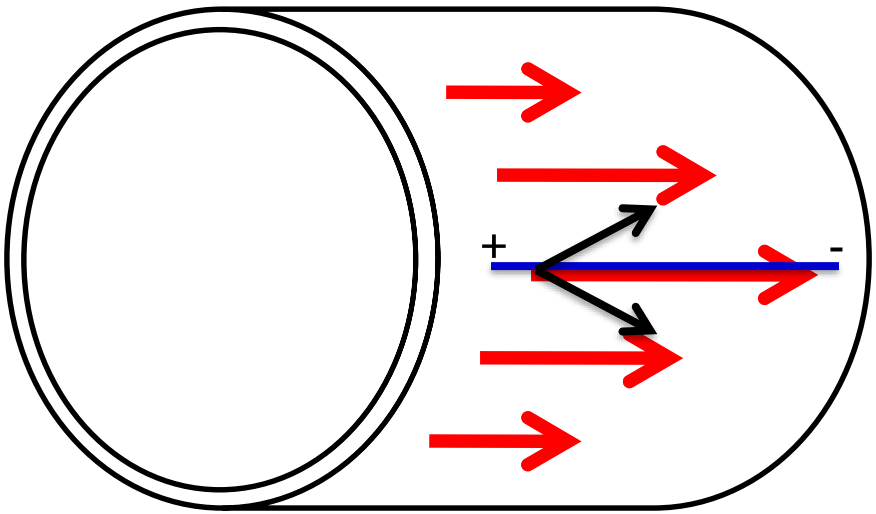


- Active shielding coil (NbTi) for electrons
  - Tapered?
  - Passive shielding on inside to take care of residual field
- Pros
  - Variable field?
  - Additional room for detectors
  - Size and weight down
- Cons
  - Field quality protons
  - Add. complexity of SC magnet
  - cost

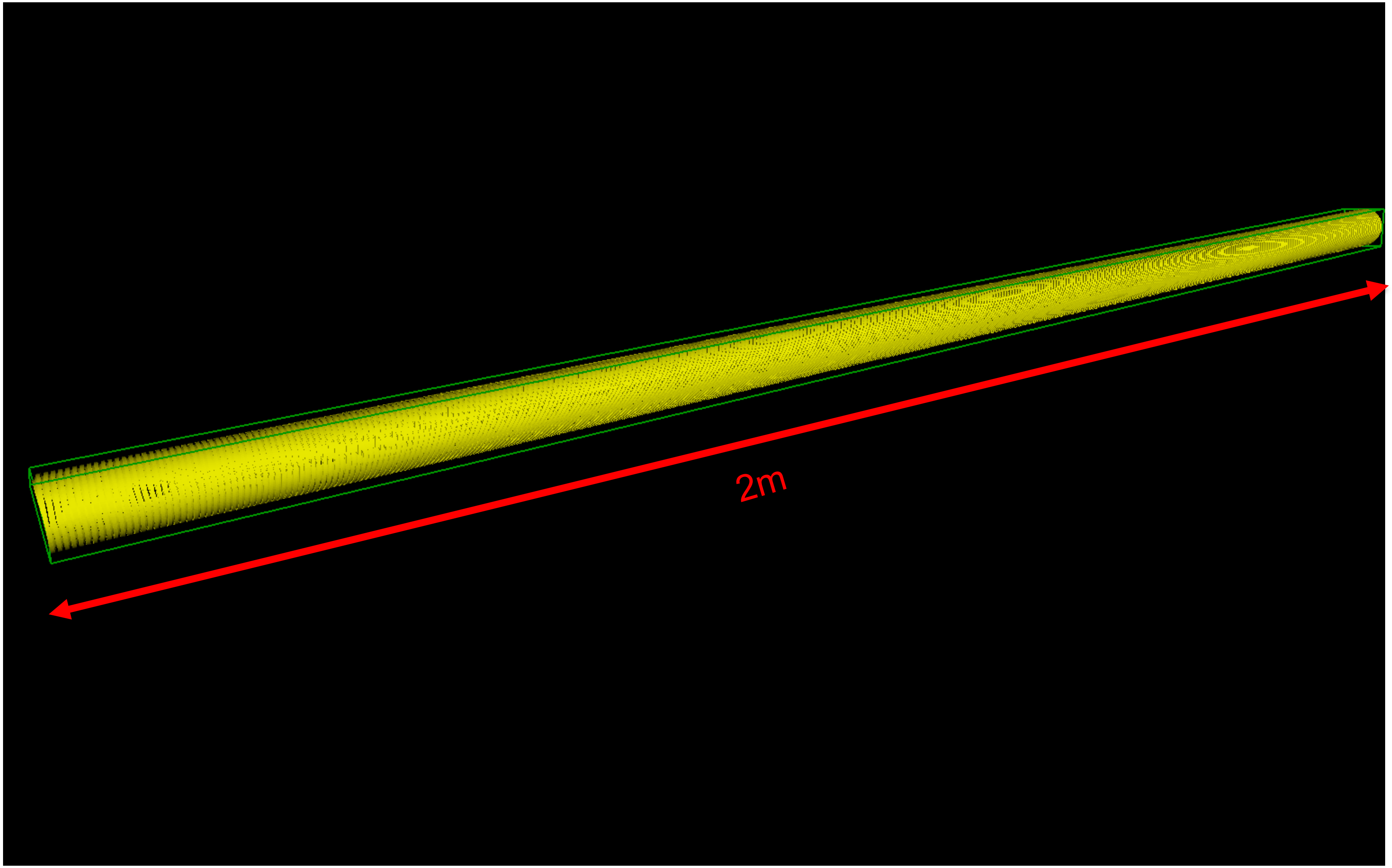
Implementation: Helical Coil

- One example how this can be done
- Helical coils: cosine theta magnet
- Need at least two layers
  - In practise: four
- Better performance than conventional coils
  - Field quality
  - maximum field
- Flexibility: Superposition of two currents
  - Any multipole (or combination of)

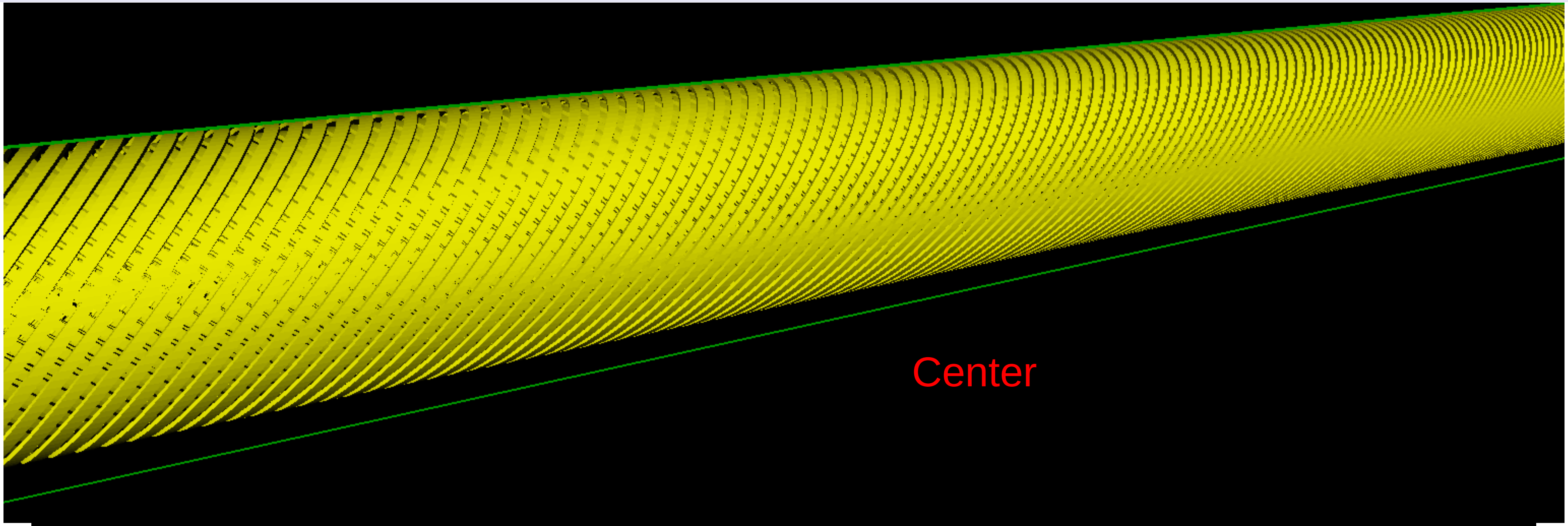


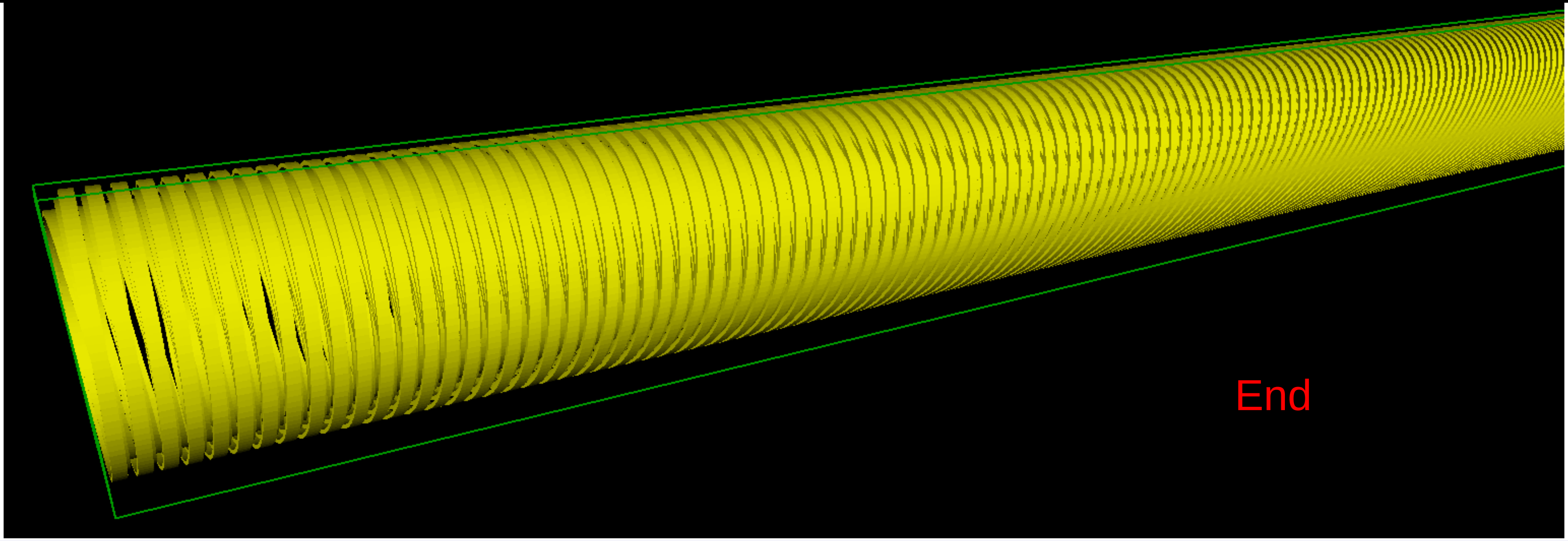


B0 Compensation Dipole

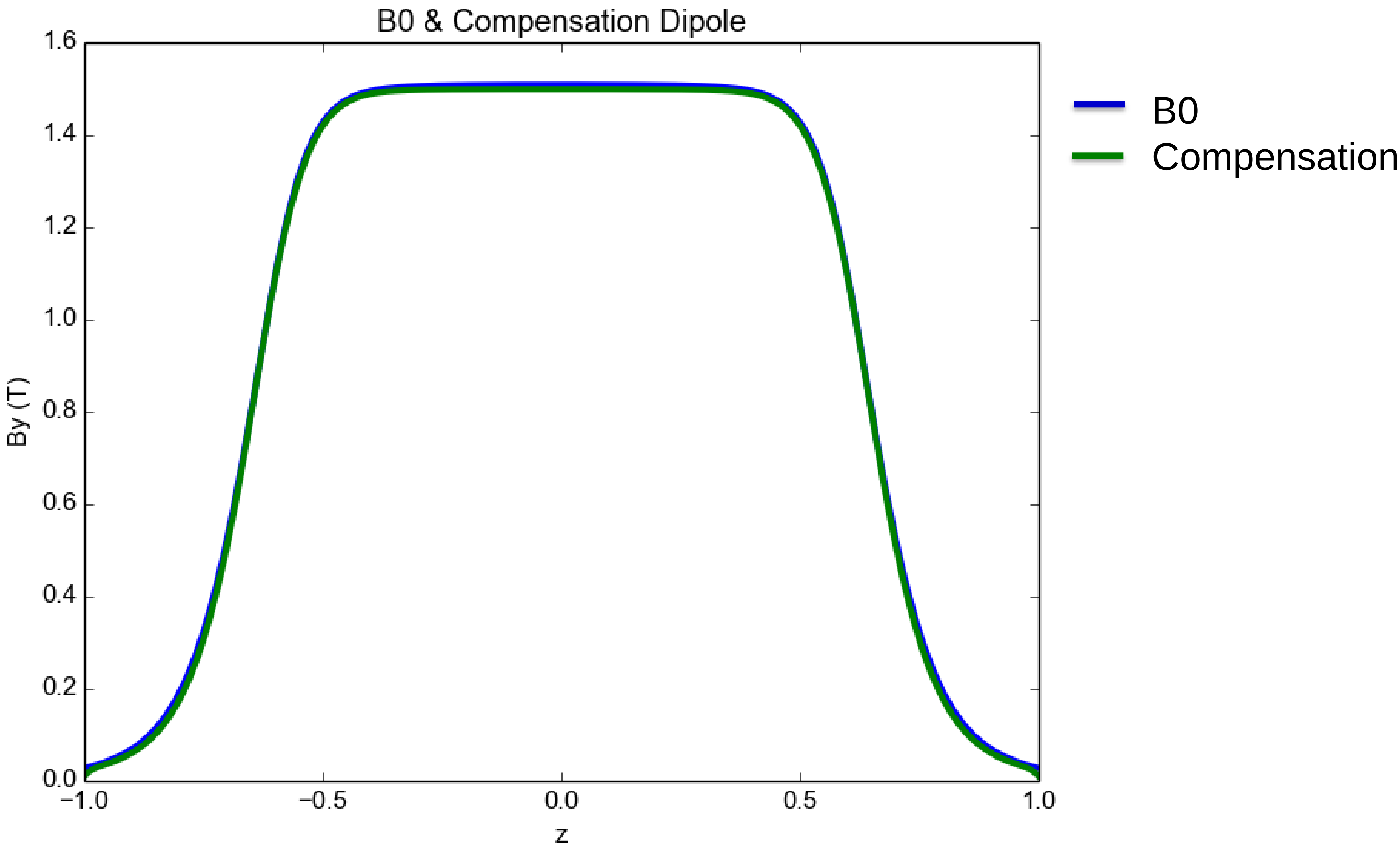


B0 Compensation Dipole

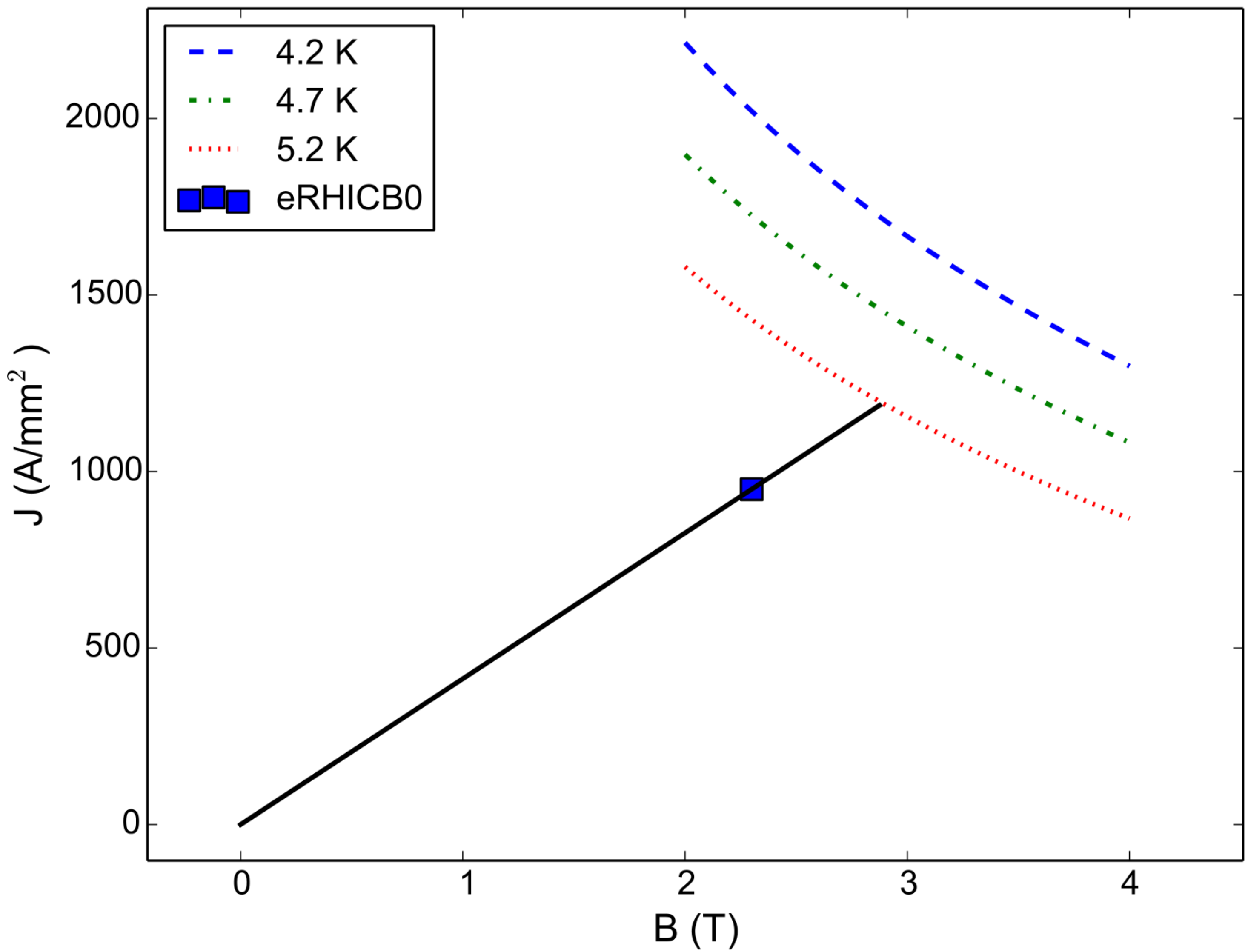




Compensation Field

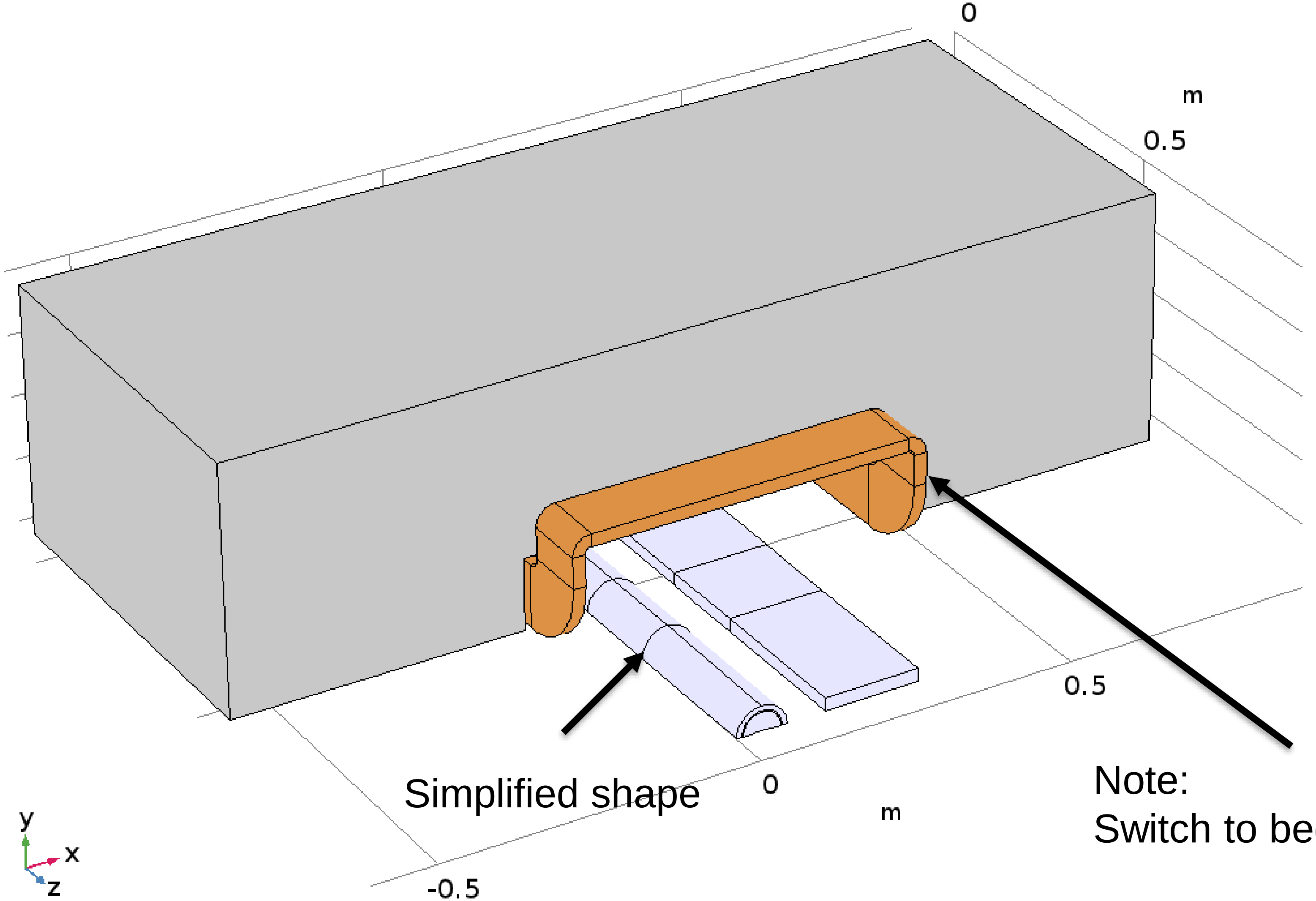


Load Line



B0 3D Model

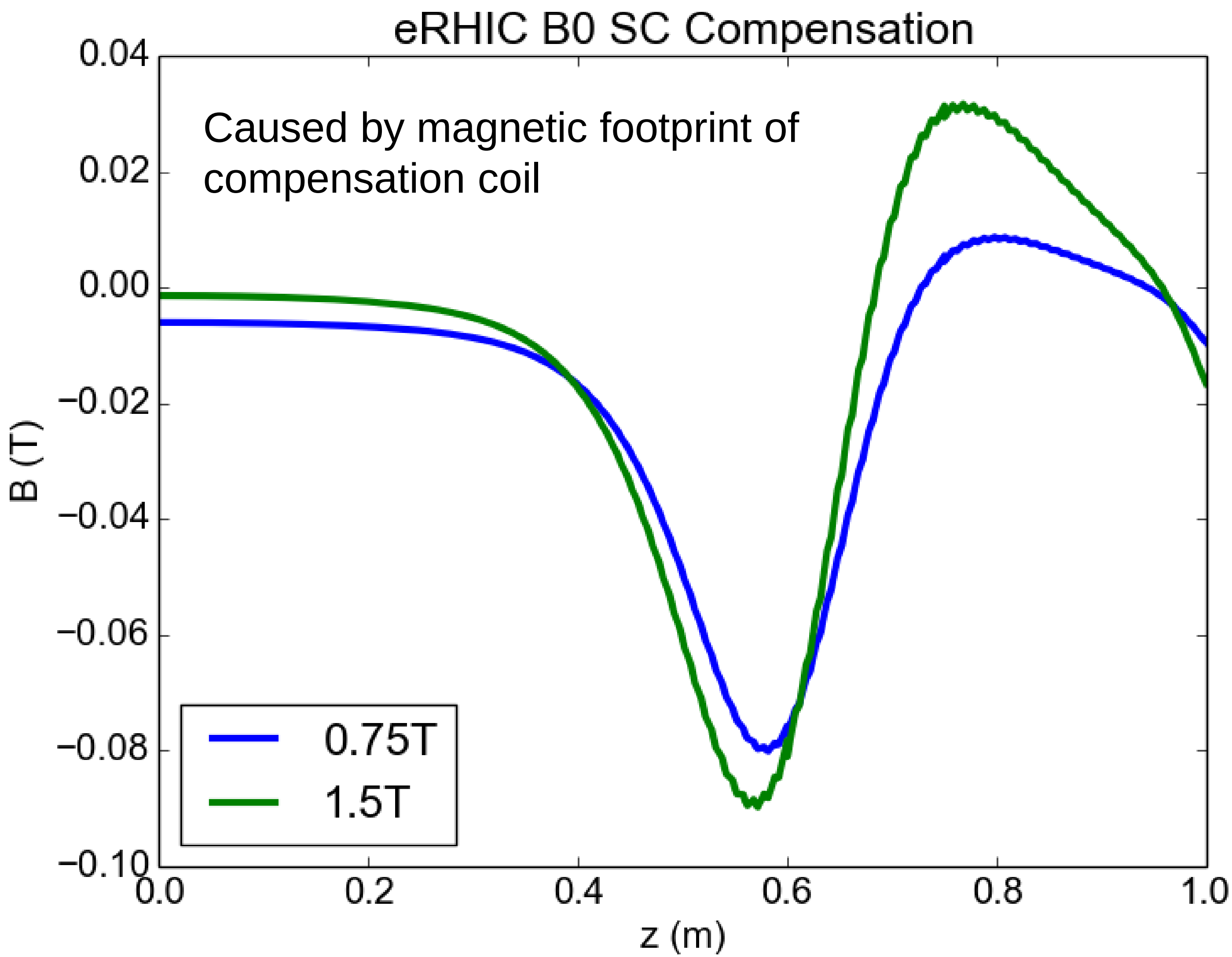
Iron: 10 tons



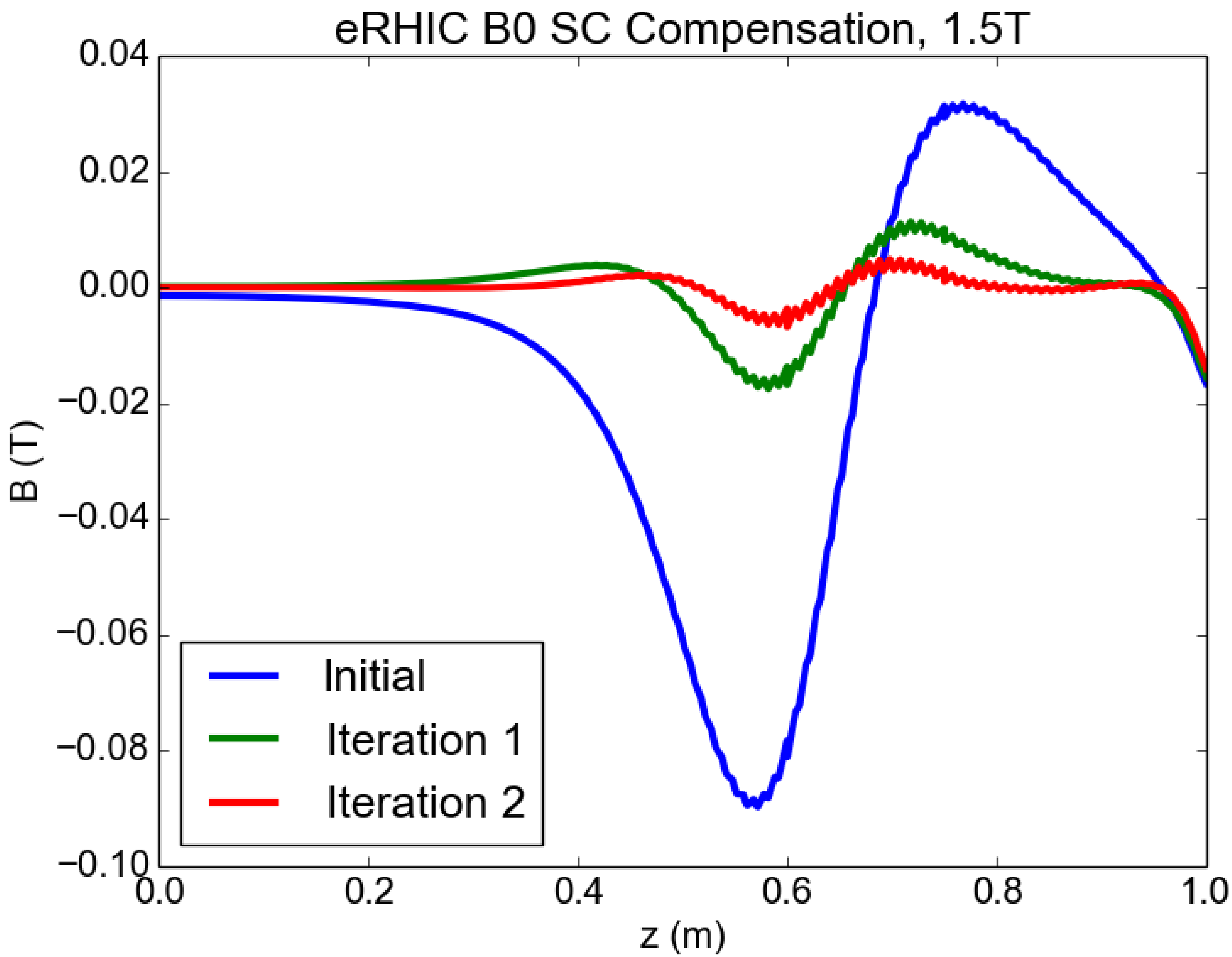
Simplified shape

Note:
Switch to bedsted coil

Crosstalk – Residual Field Electrons



Iterative Improvement



Expected Residual Field at 0.75T

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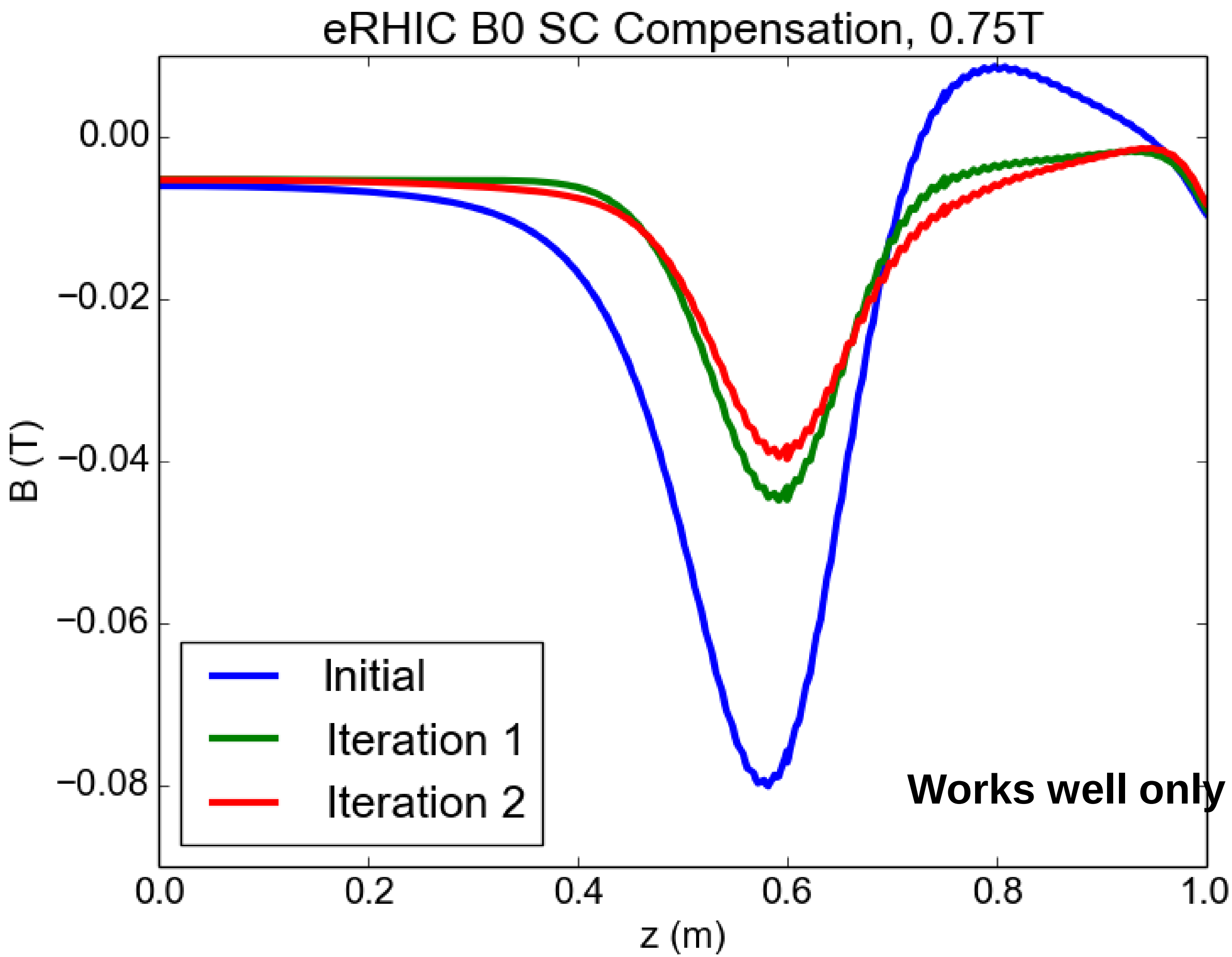
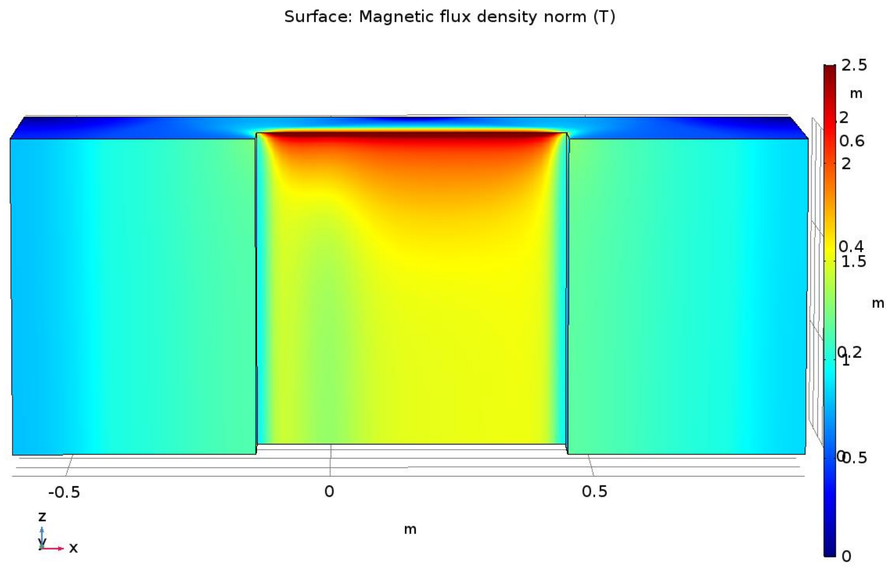
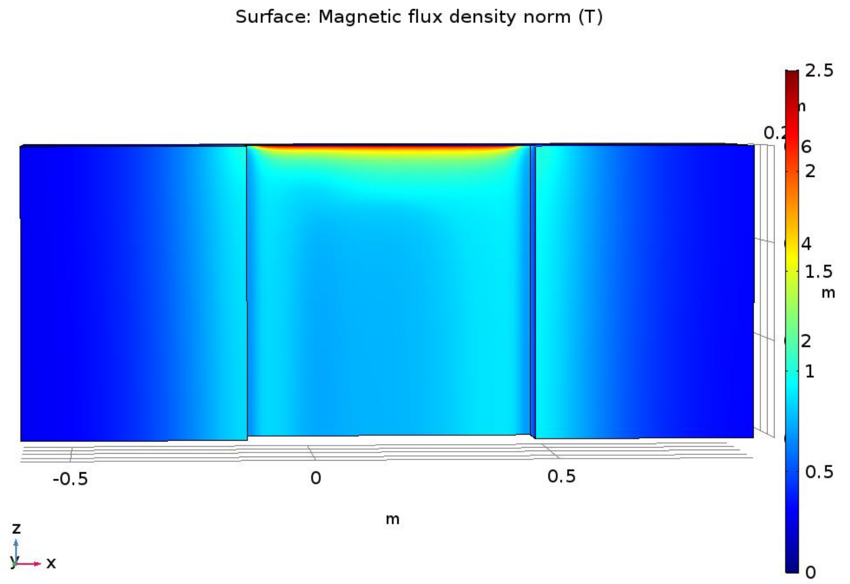


Works well only for one field

Yoke Magnetization

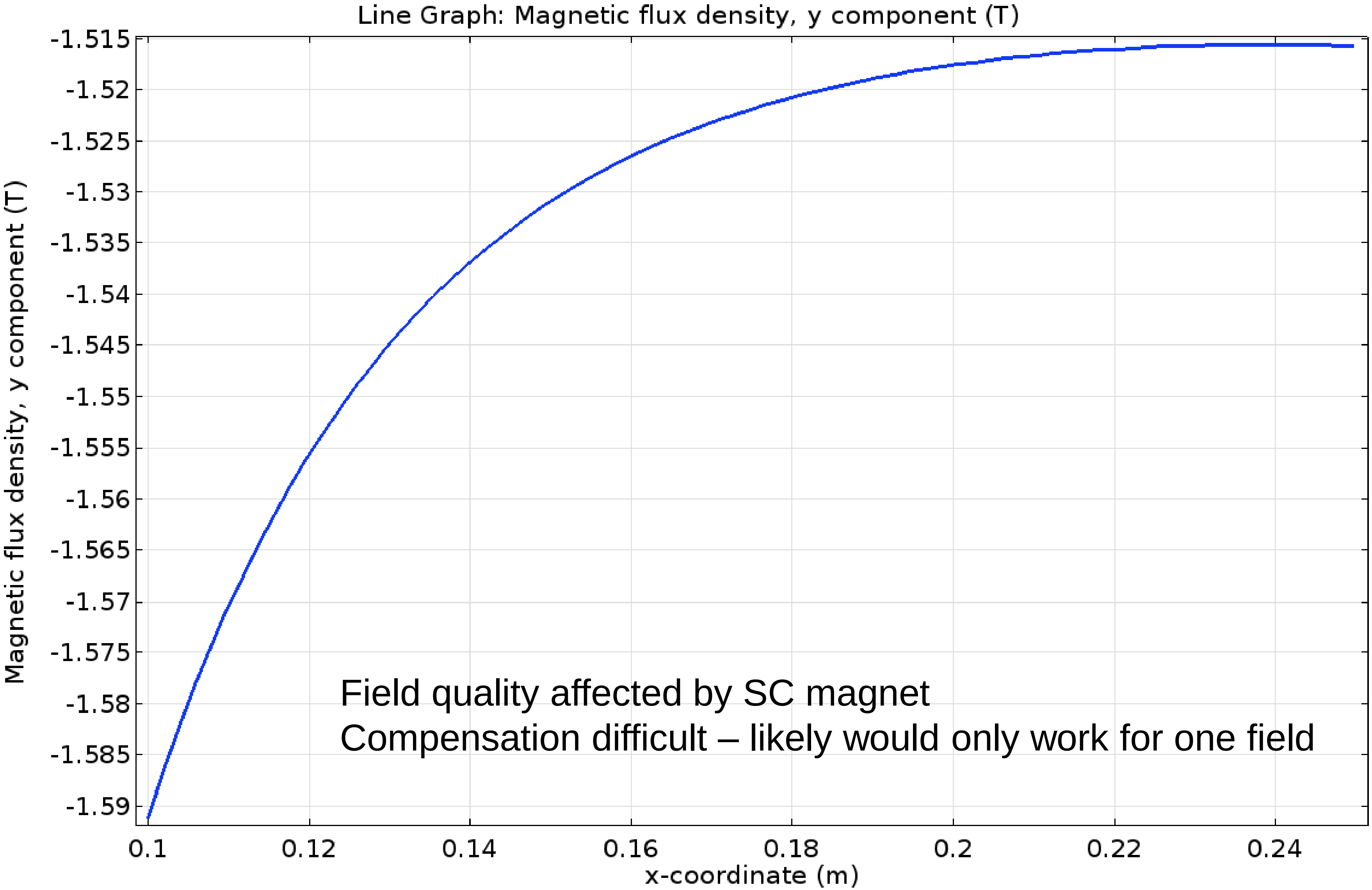


0.75T



1.5T

Field Hadrons Centre Plane



Field quality affected by SC magnet
Compensation difficult – likely would only work for one field

Summary

	Septum	Compensation coil	Halbach
Shielding e-	++	++	++
Field quality hadrons	+	--	++
Detector space	--	+	++
Variable field	++	O[1)]	-[2)]
Size/weight	--	+	+
Cost	++	--	O
Risk	++	?	+[3)]
Cryogenics	RT	4.2K	77K

1) Affects field quality and residual field e^-
2) Requires separate Halbach magnets / more complicated design
3) Risk is demagnetization – can be tested inexpensively

Conclusion

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- Three options for B0
- Septum Design: low risk
  - Variable field
  - Limited space for detectors
  - Large and heavy
- Halbach design: more space for detectors
  - Limited risk
  - Fixed field (live with one field, swap magnets, …)
- Superconducting compensation: variable field
  - More complex design
  - Less space
  - Crosstalk / field quality issues: tolerable?
  - Some practical issues

Radius Halbach Magnet