Karlsruhe Institute of Technology

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Compliance of Numerical Formulations for Describing Superconductor/Ferromagnet Heterostructures

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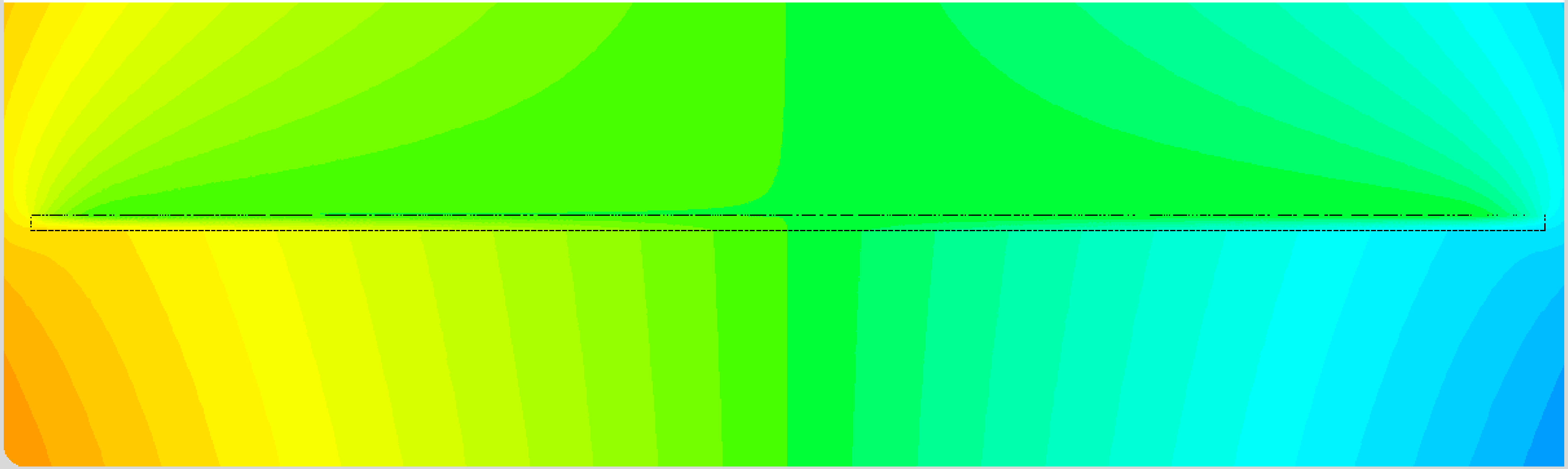


Synopsis

- Introduction
- Geometries
- Results
- Conclusion

Introduction

- Edge-element model [1]
  - Comprehensive model
  - time dependent
  - based on power-law

- Electrostatic-magnetostatic analogy model [2]
  - Fast but limited to specific problems (in present state)
  - time independent
  - Based on Bean-model

Introduction

Efficiency comparison: simple geometry

Edge-element model

- Degrees of freedom: 50-100k
- Time-Steps: 100 (1 full cycle)
- Runtime
  - Low fields: ~ 10-30 min
  - High fields: ~ 2-5 h

- Great flexibility but long computation

Analogy model

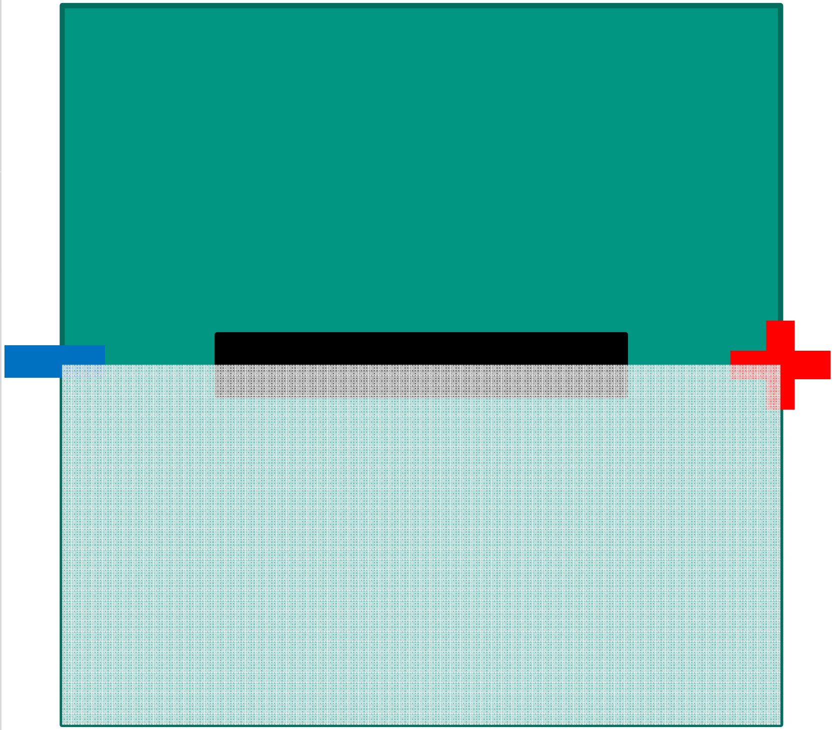
- Degrees of freedom: 50-100k
- Time-Steps: 1 (maximum field)
- Runtime under 5 min

- Specific problems only but blazing fast

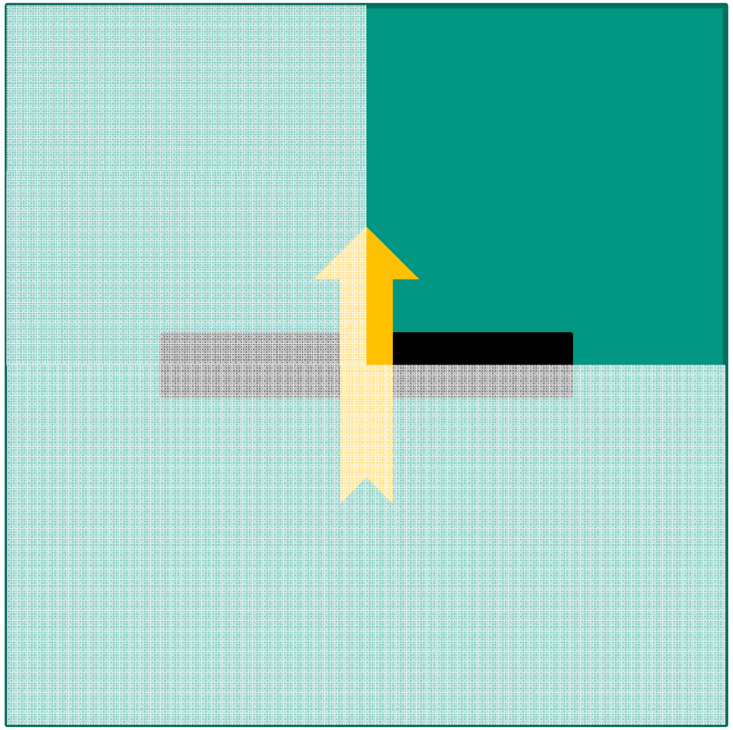
Introduction

Optimising the computation

Case of applied field



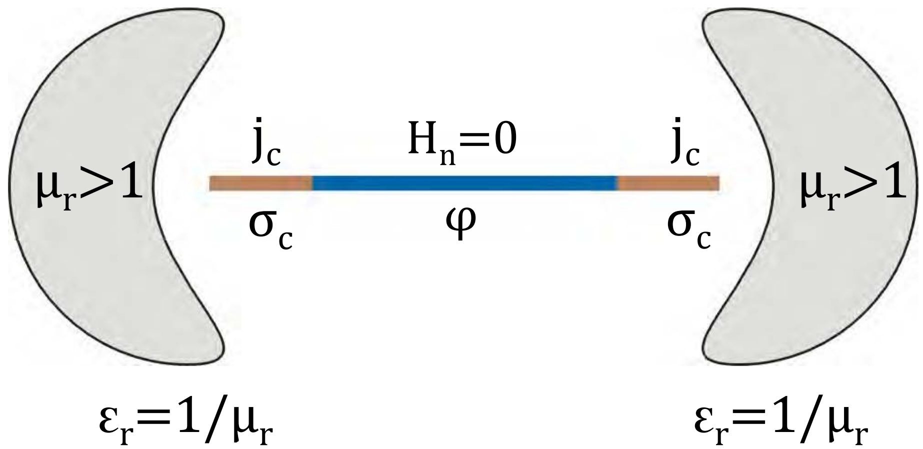
Case of applied current



Introduction

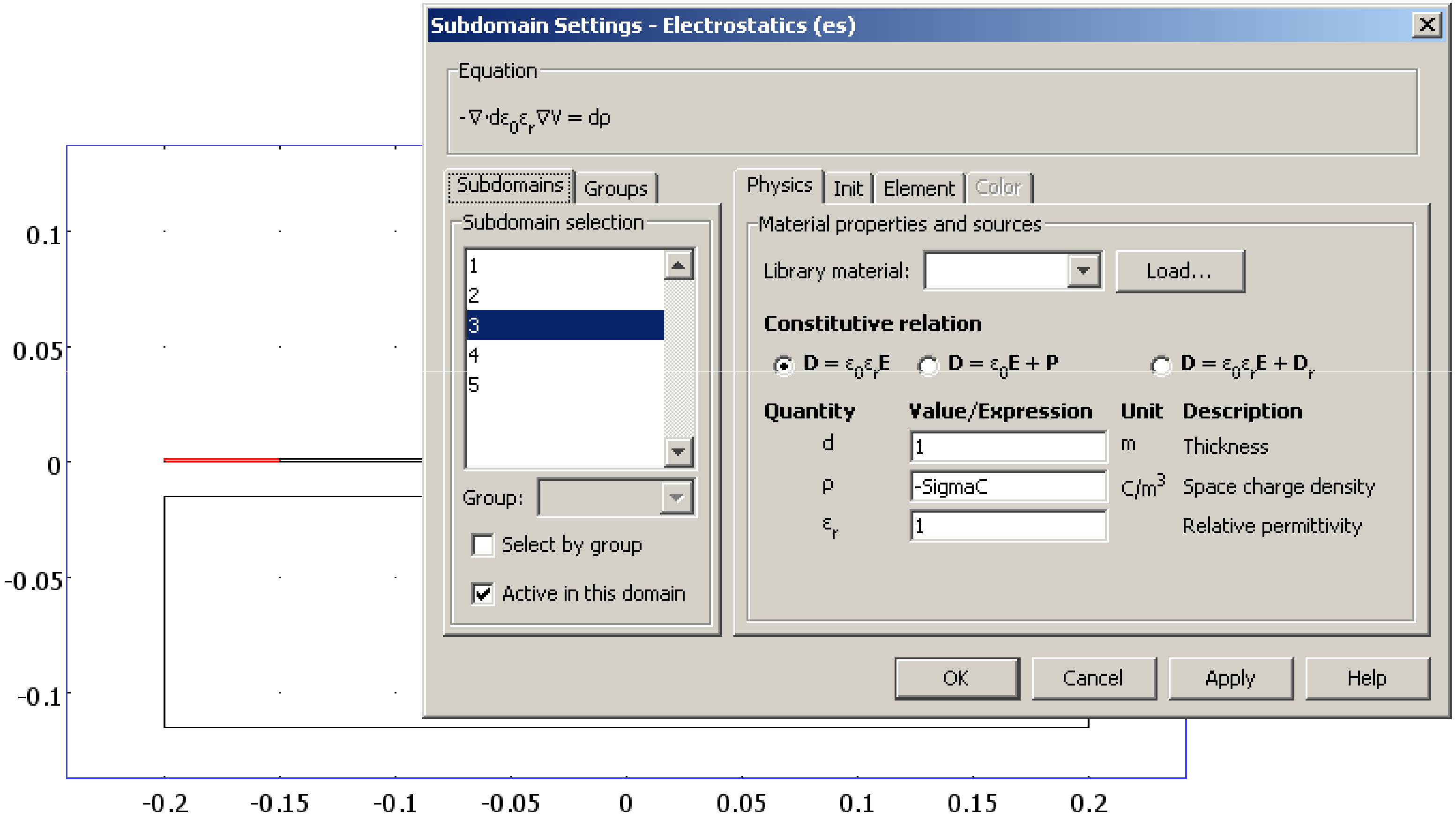
Electrostatic-magnetostatic analogy model: principle of operation

- Analogy between electrostatic and magnetostatic properties used to model superconductor/ferromagnetic behaviour
- Self-consistent result must be obtained via variation of parameters (continuety of current profiles)



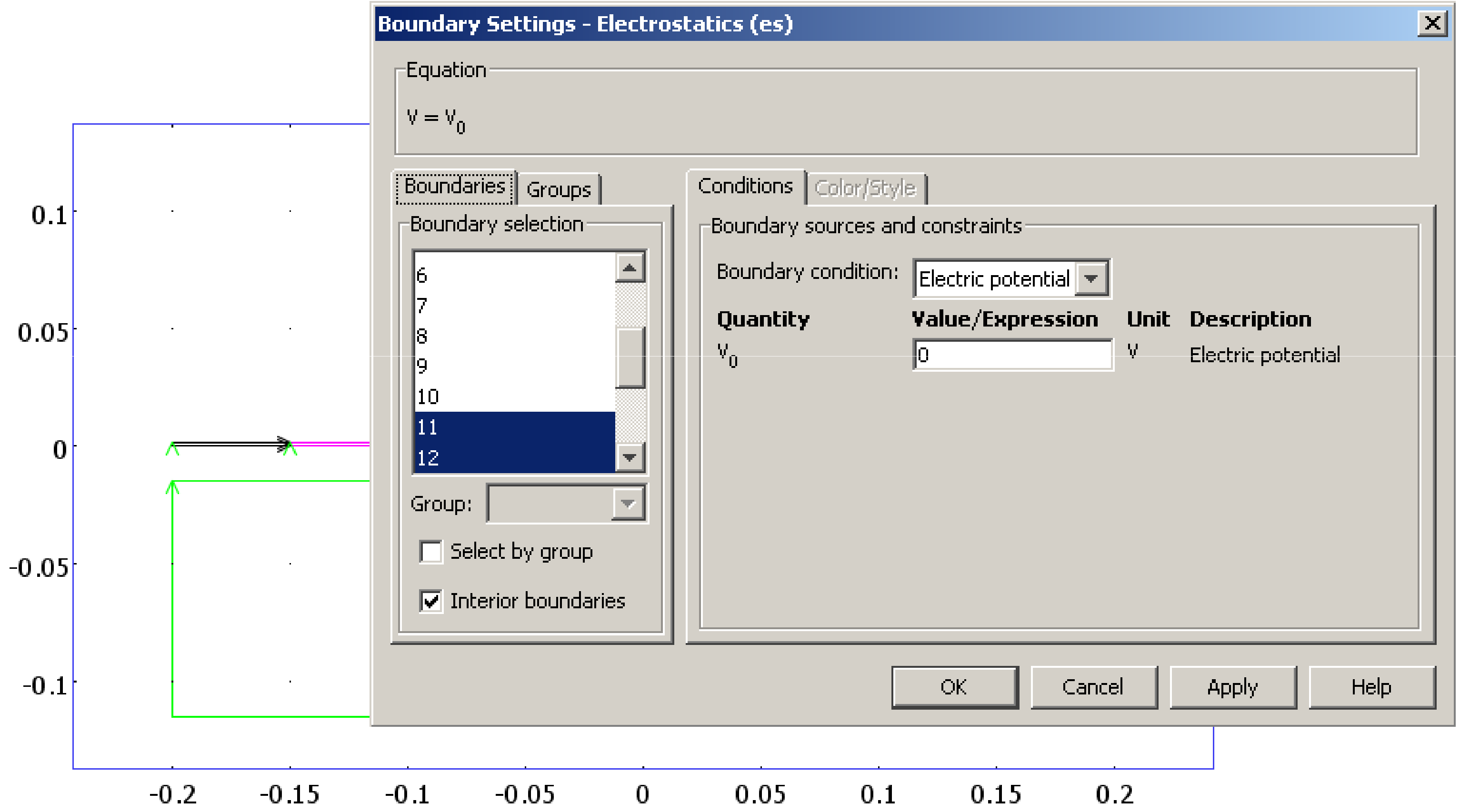
Introduction

Electrostatic-magnetostatic analogy model: implementation



Introduction

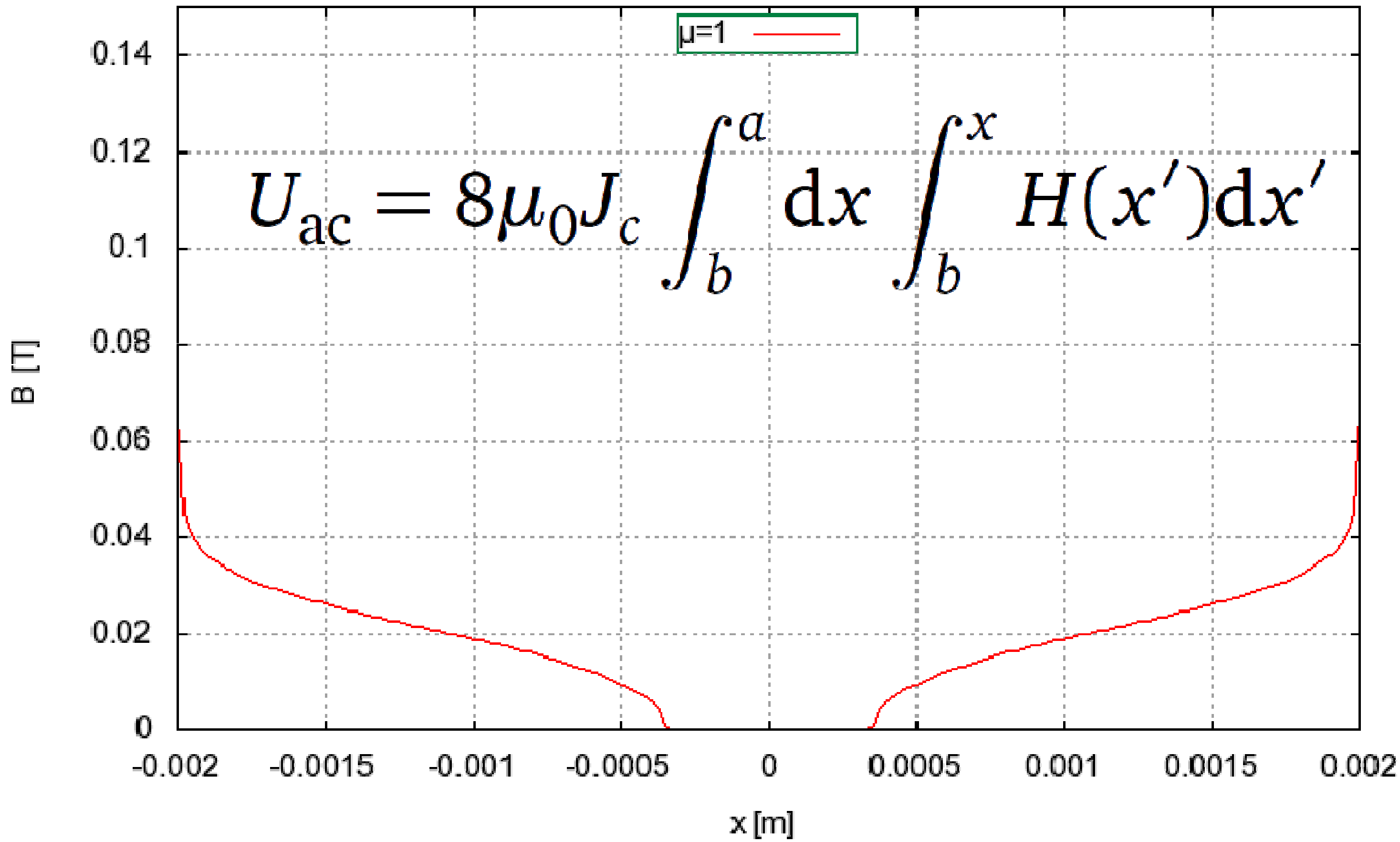
Electrostatic-magnetostatic analogy model: implementation



Introduction

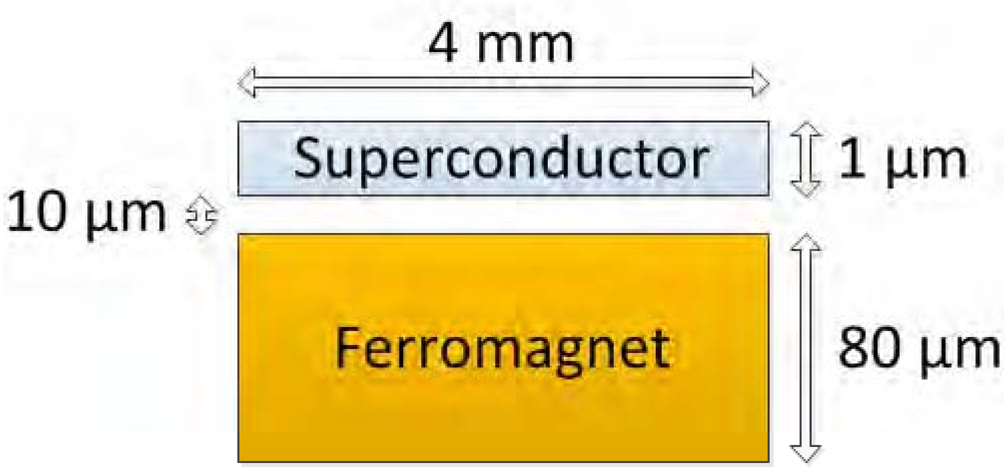
- Coated conductor: field profiles and ac-loss

$$U_{\mathrm{ac}} = 8\mu_0 J_c \int_b^a \mathrm{d}x \int_b^x H(x')\mathrm{d}x'$$

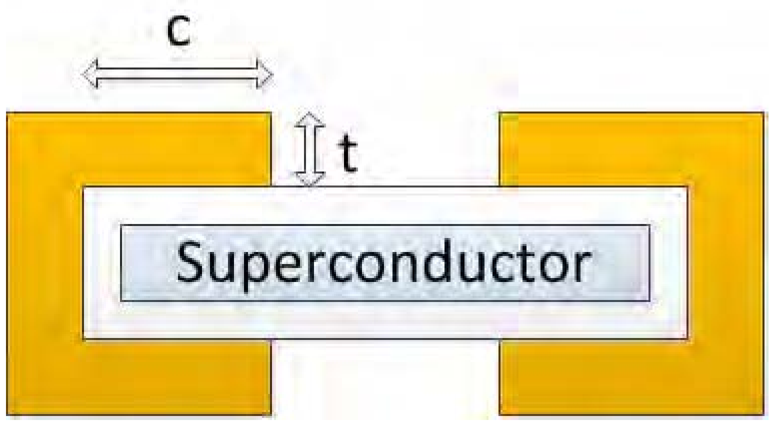


Geometries

- RABiTS Coated Conductor

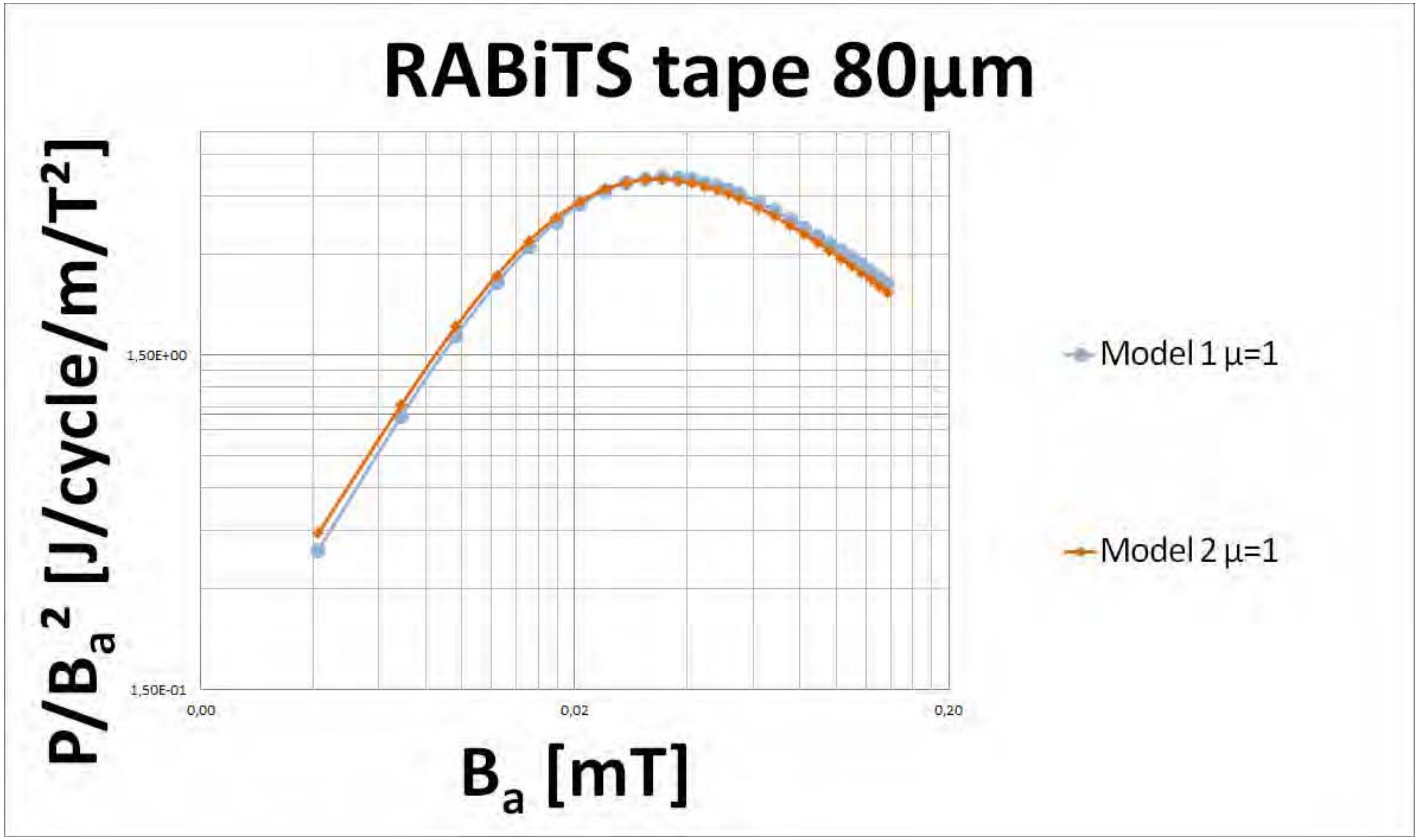


- Horseshoe shielding



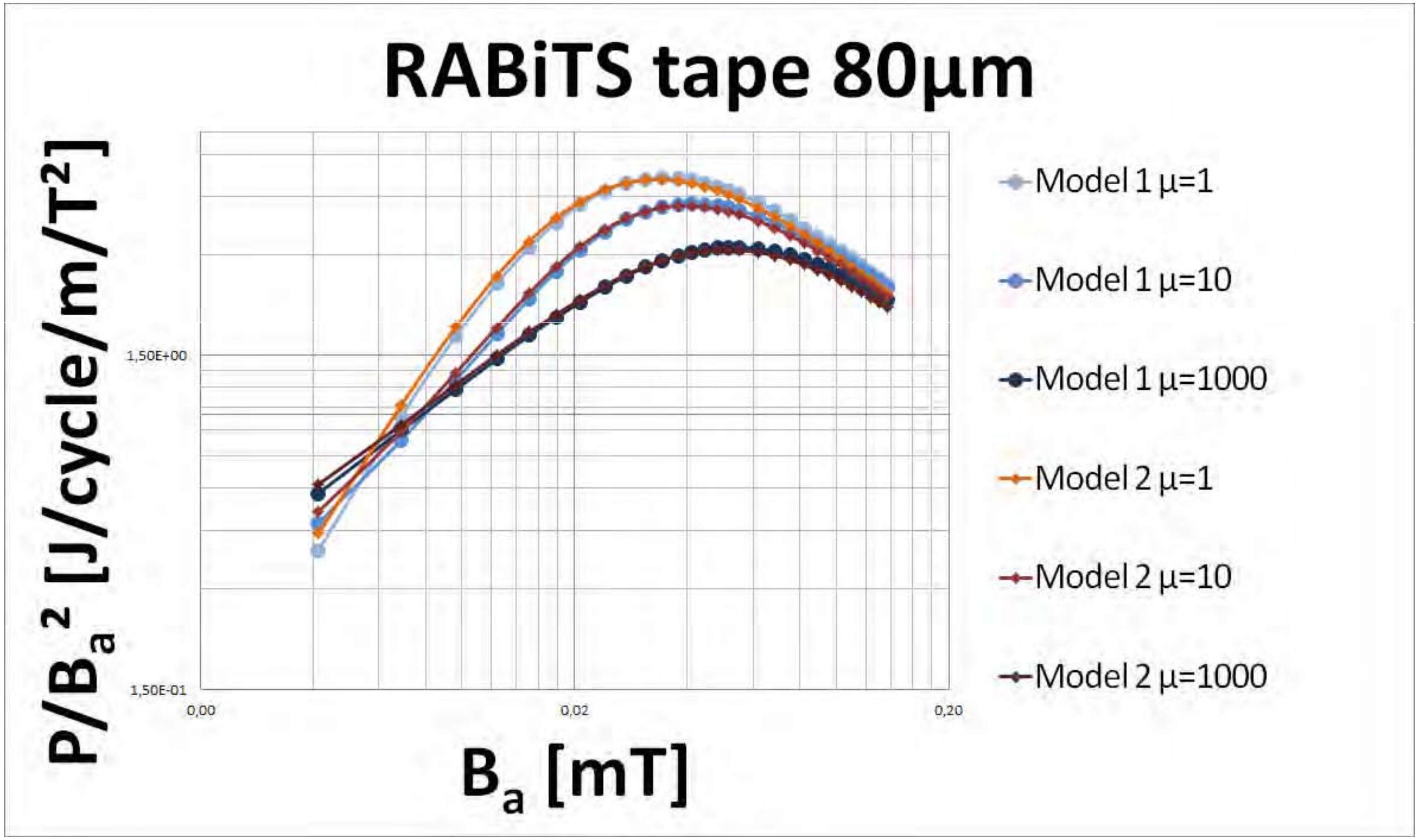
Results

- Coated conductor with non-magnetic substrate: loss characteristic



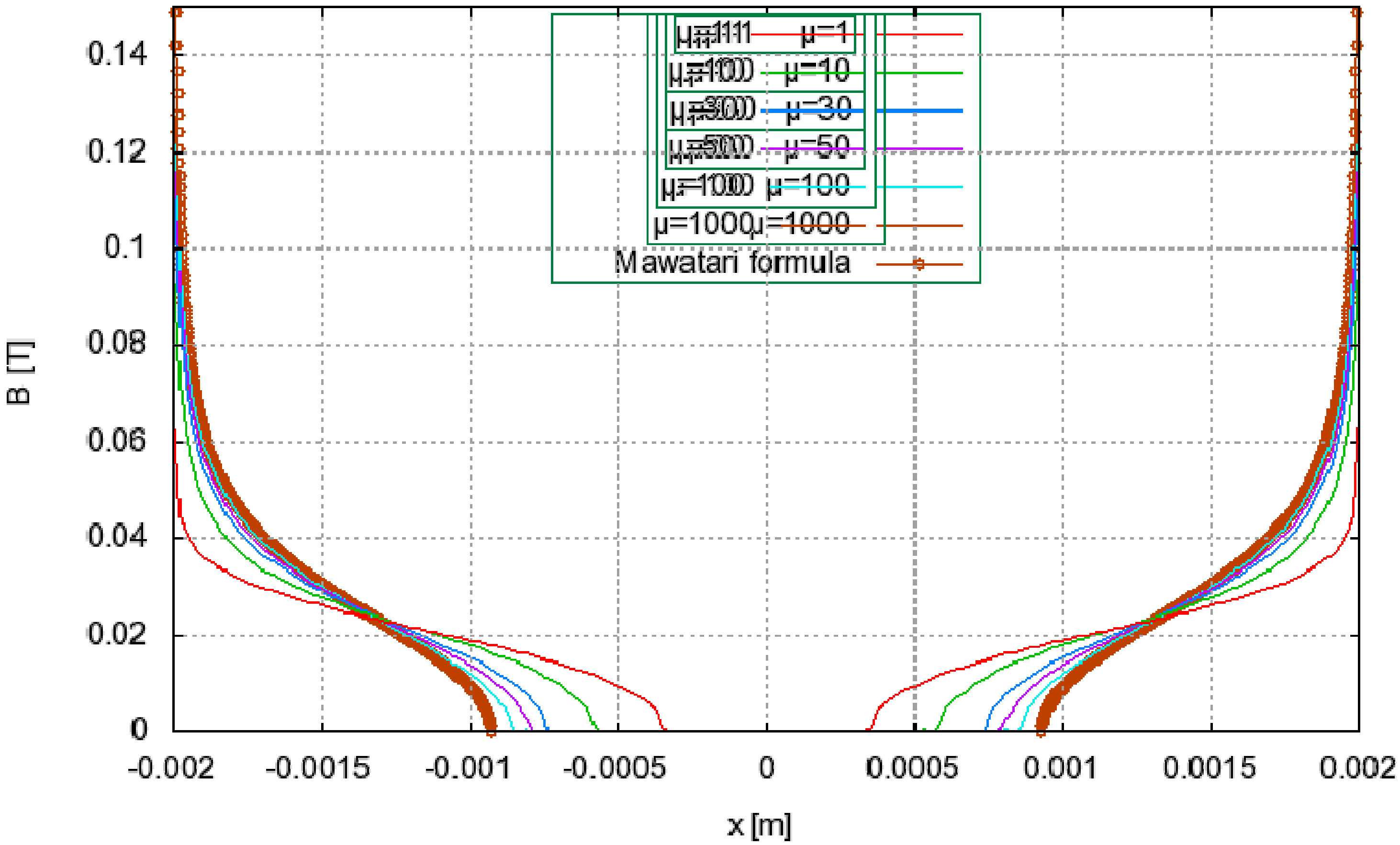
Results

- Coated conductor: effect of substrate with varying µ



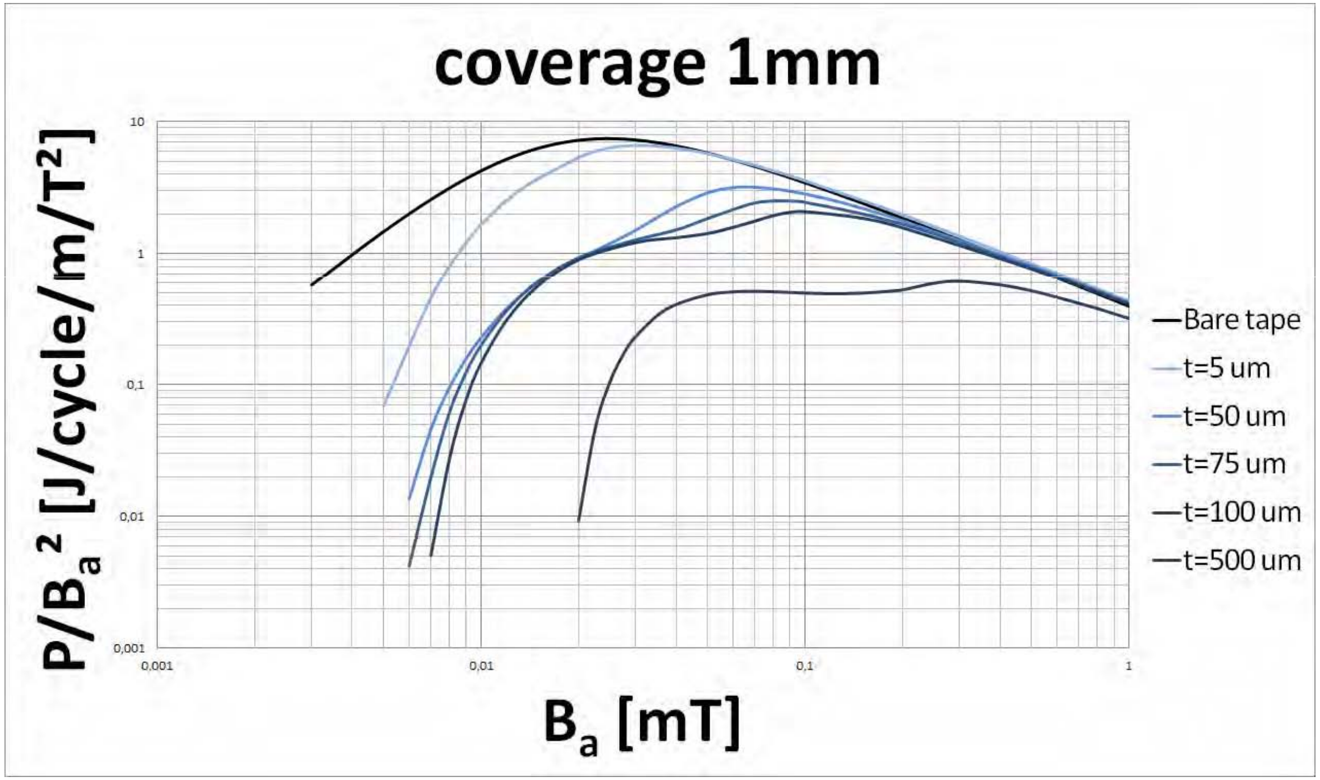
Results

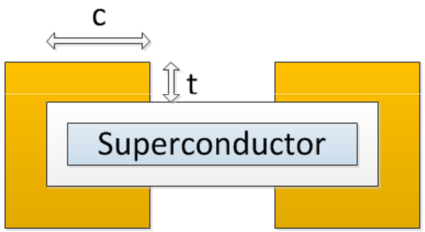
- Coated conductor: field profiles



Results

- Horseshoe shielding: loss characteristics





Conclusions

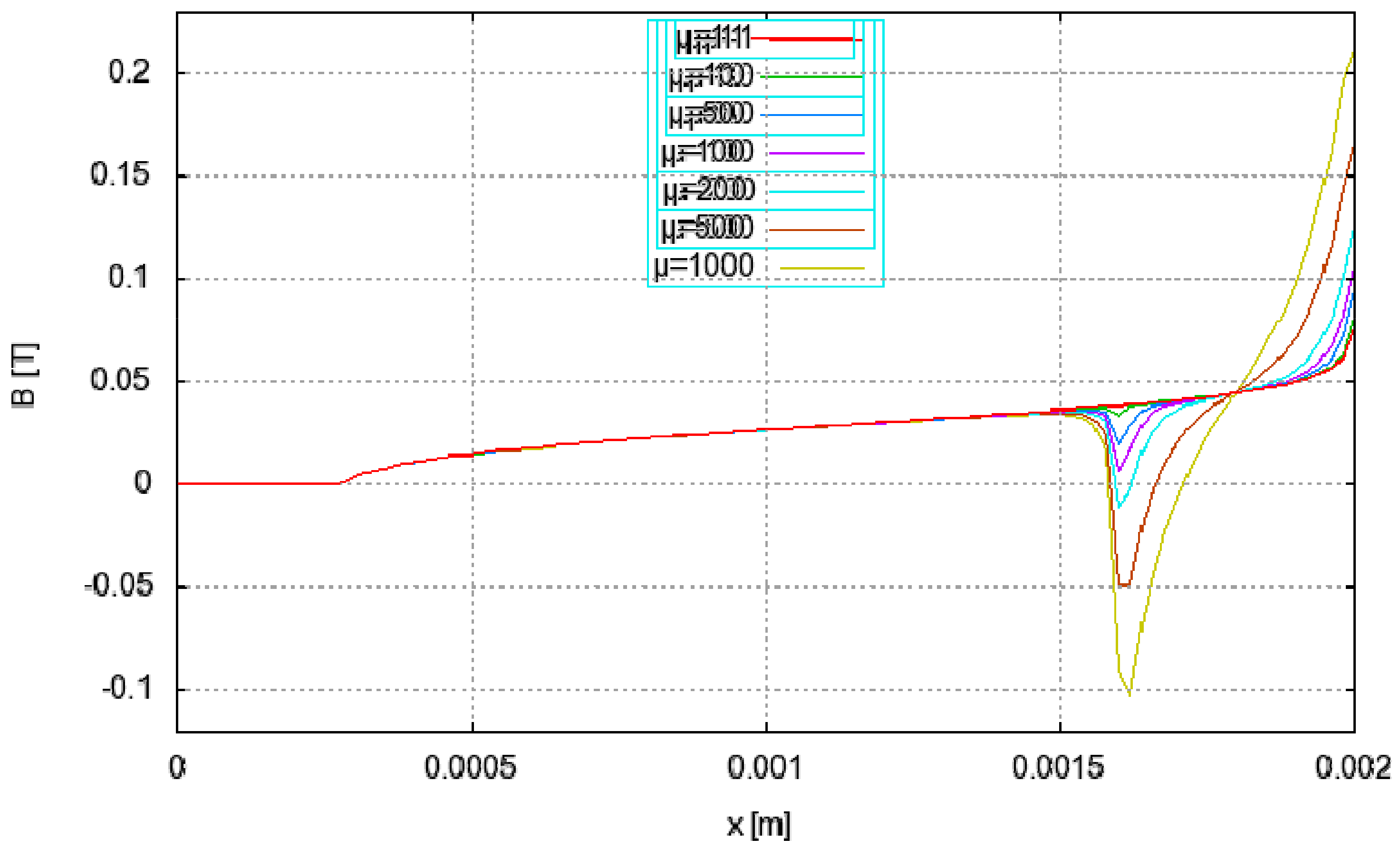
- All investigated models are interchangeably applicable
  - Use model best suited to problem (speed, complexity)
- Next up:
  - Account for losses in ferromagnetic material
  - Investigate other geometries and case of self field
  - Validate simulations by experimental results
- Goal:
  - Apply knowledge to technical appliances (generators, transformers, motors, cables)

Thank you for your attention!

- [1] R. Brambilla, F. Grilli, L. Martini, Supercond. Sci. Technol. **20** (2007) 16–24
- [2] Y. Genenko, H. Rauh, P. Krüger, N. Narayanan, Supercond. Sci. Technol. **22** (2009) 055001/1–14

Results

- Horseshoe shielding: field profiles, varying permeability



Results

- Horseshoe shielding: field profiles, varying thickness