Rapid Cycling Dipole Magnet

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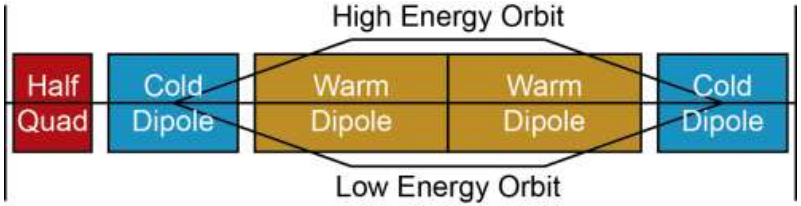
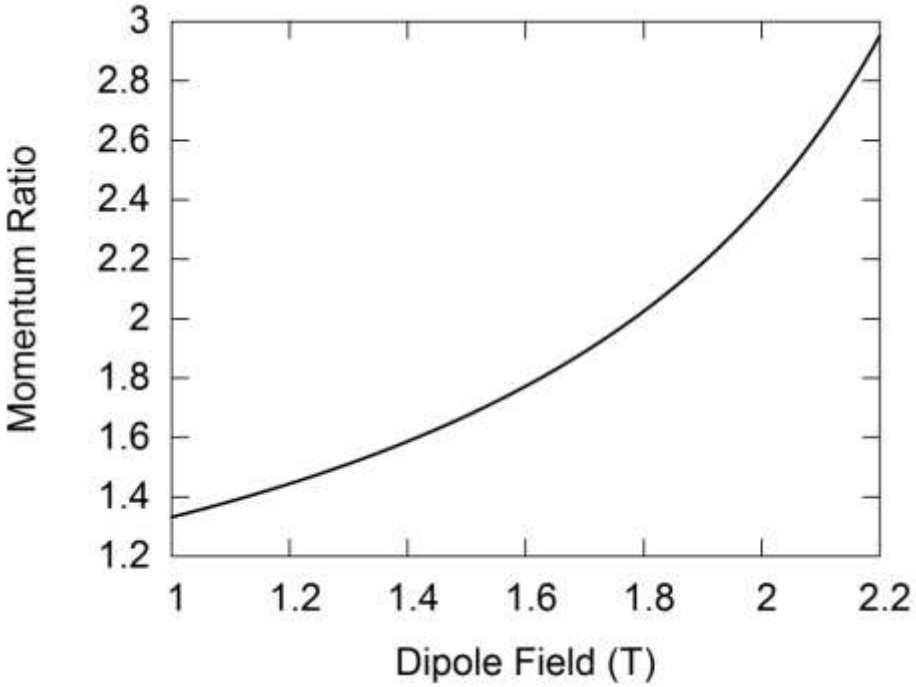
Overview

- Motivation
- Materials
- Performance
- Losses
- Engineering

Rapid Cycling Synchrotron

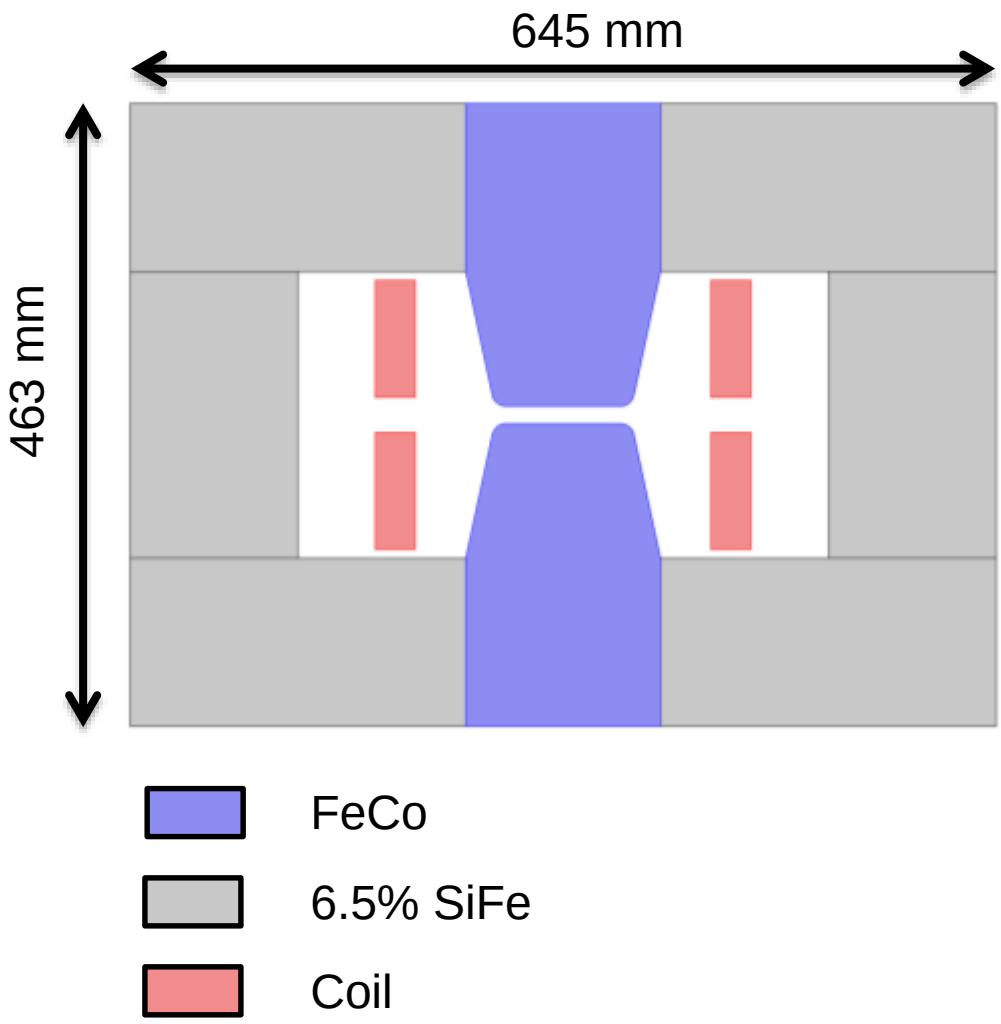
- Final acceleration Muon Collider: RCS
  - Interleaved cold and warm dipoles
- Warm dipoles: correct average bend field
  - must change rapidly (>400 Hz)
- Maximum warm dipole field: significant impact
  - Larger energy range
  - Higher maximum energy
  - Shorter circumference
  - Fewer accelerator stages





Magnet Geometry

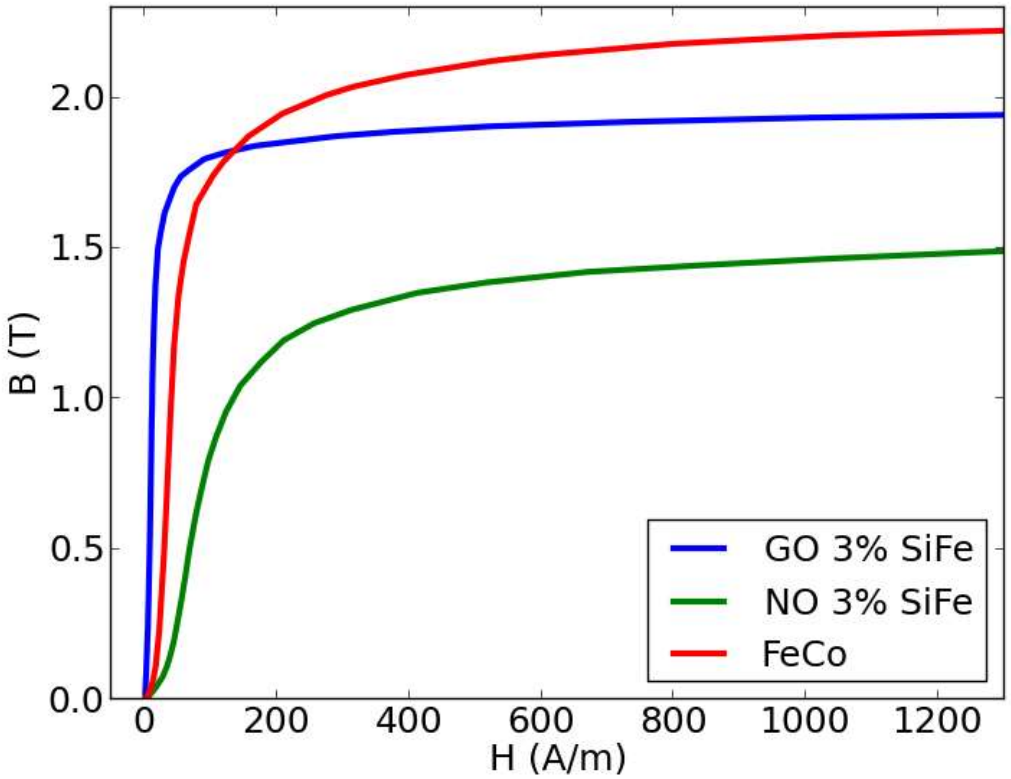
- Good field region
  - Horizontal: 60 mm
  - Vertical: 10 mm
  - Aperture: 60x13 mm^2 (option: 60x25 mm^2)
- Geometry
  - Allows to use two different materials
- Combine advantages of materials
  - Pole: FeCo
  - Yoke: 6.5% SiFe



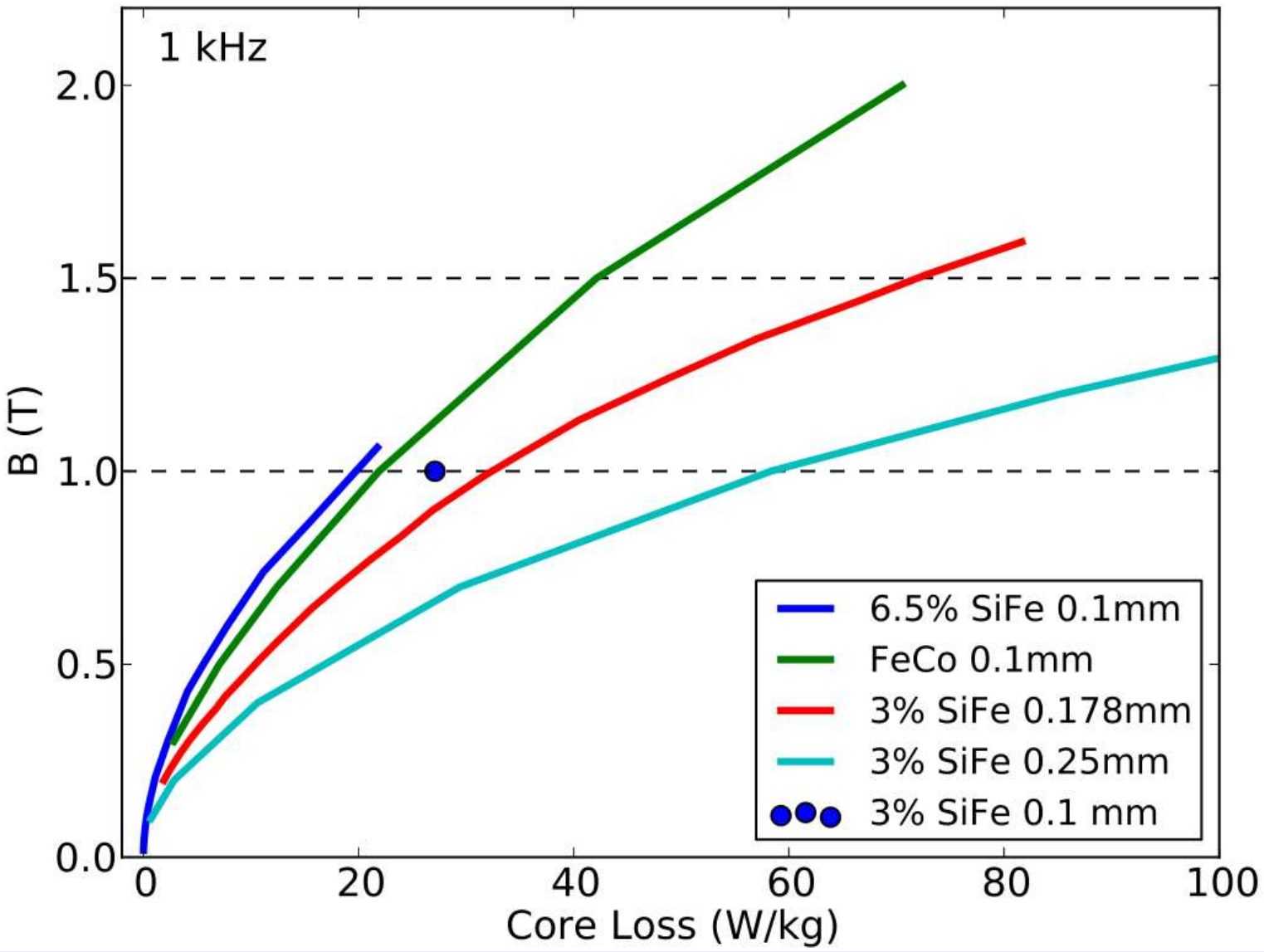
Gap: 13 mm
Pole width: 102 mm

Materials

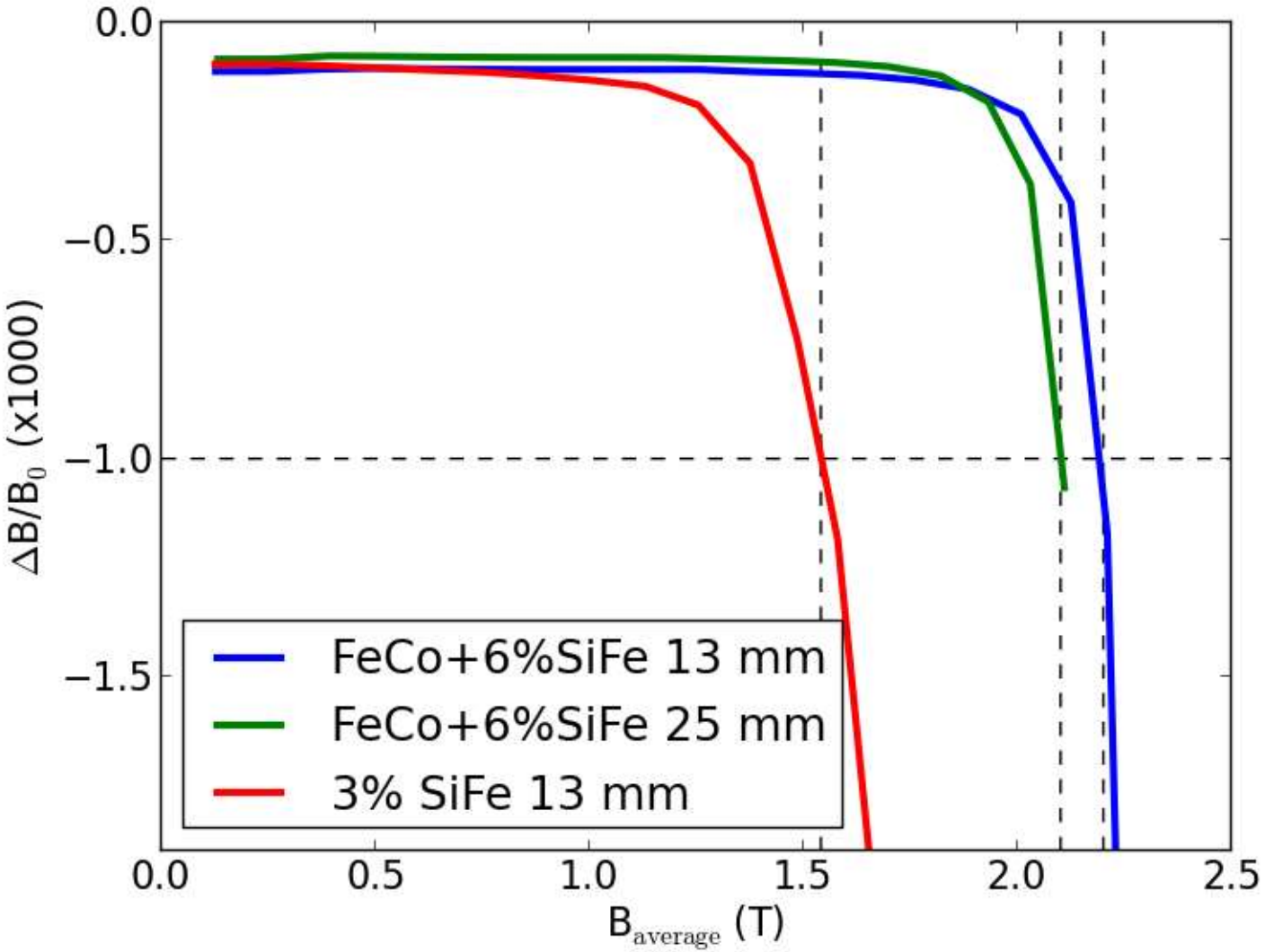
- 6.5% SiFe
  - Low losses at high frequencies
  - High permeability
  - Low saturation
- FeCo
  - High saturation
  - Higher losses
- Combine strengths of both



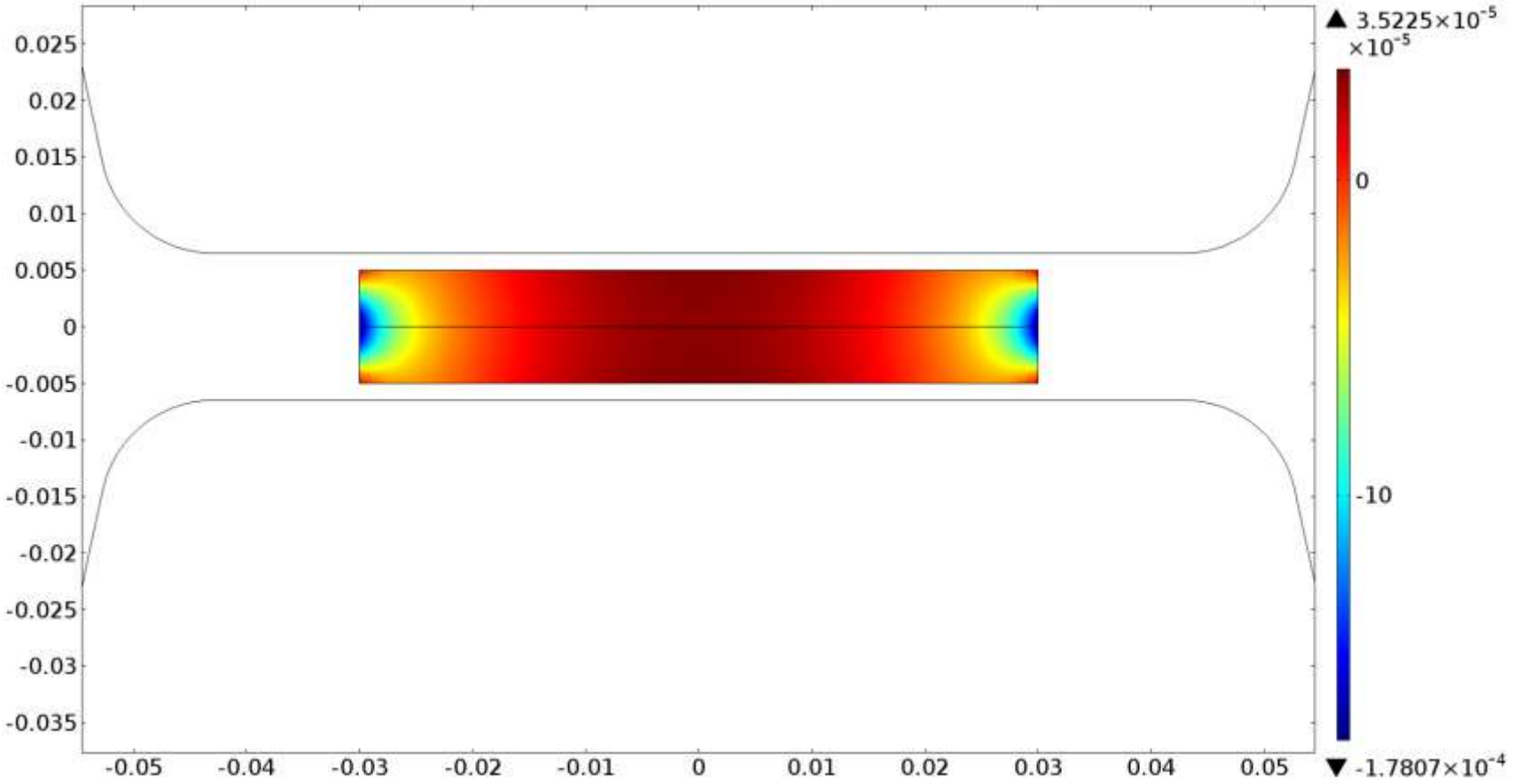
Materials - Core Losses



Field Quality

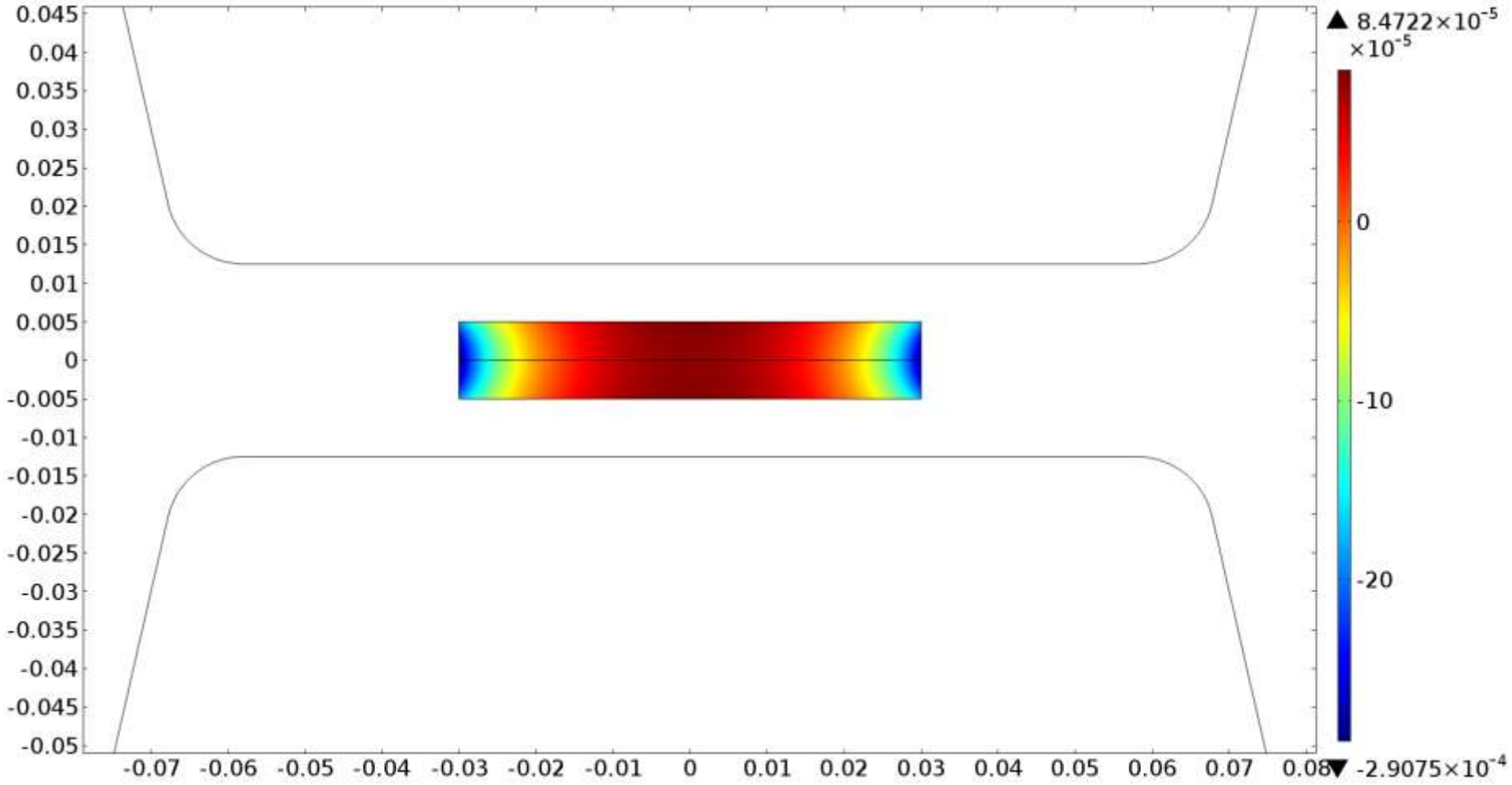


Field Quality



Dipole field: 2T
Gap: 13 mm

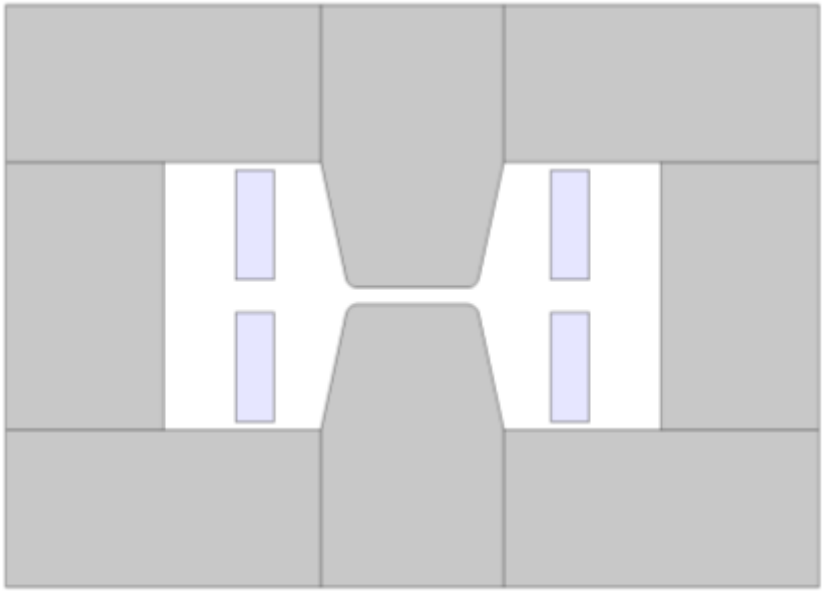
Field Quality

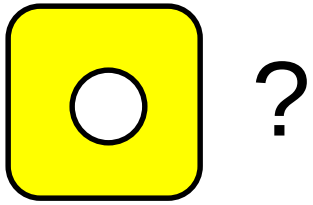


Dipole field: 2T
Gap: 25 mm

Coil

- Eddy current losses
  - Conductor shape





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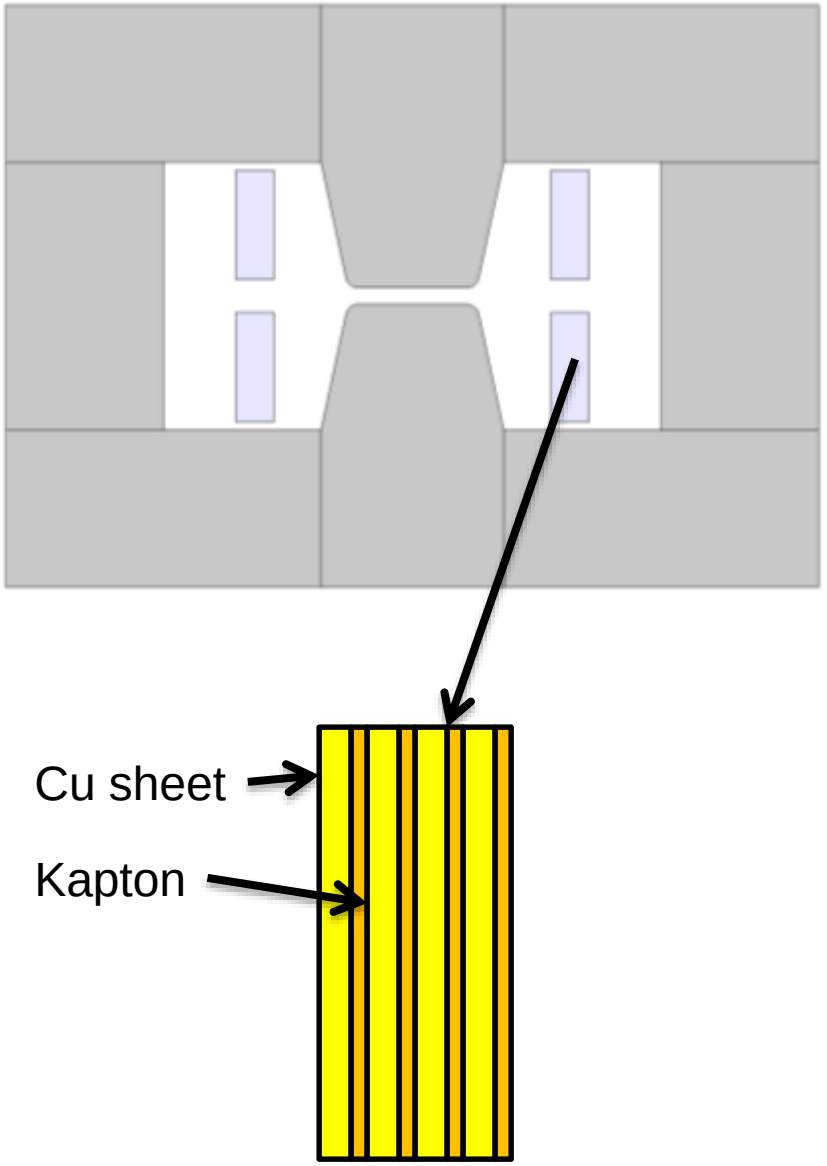
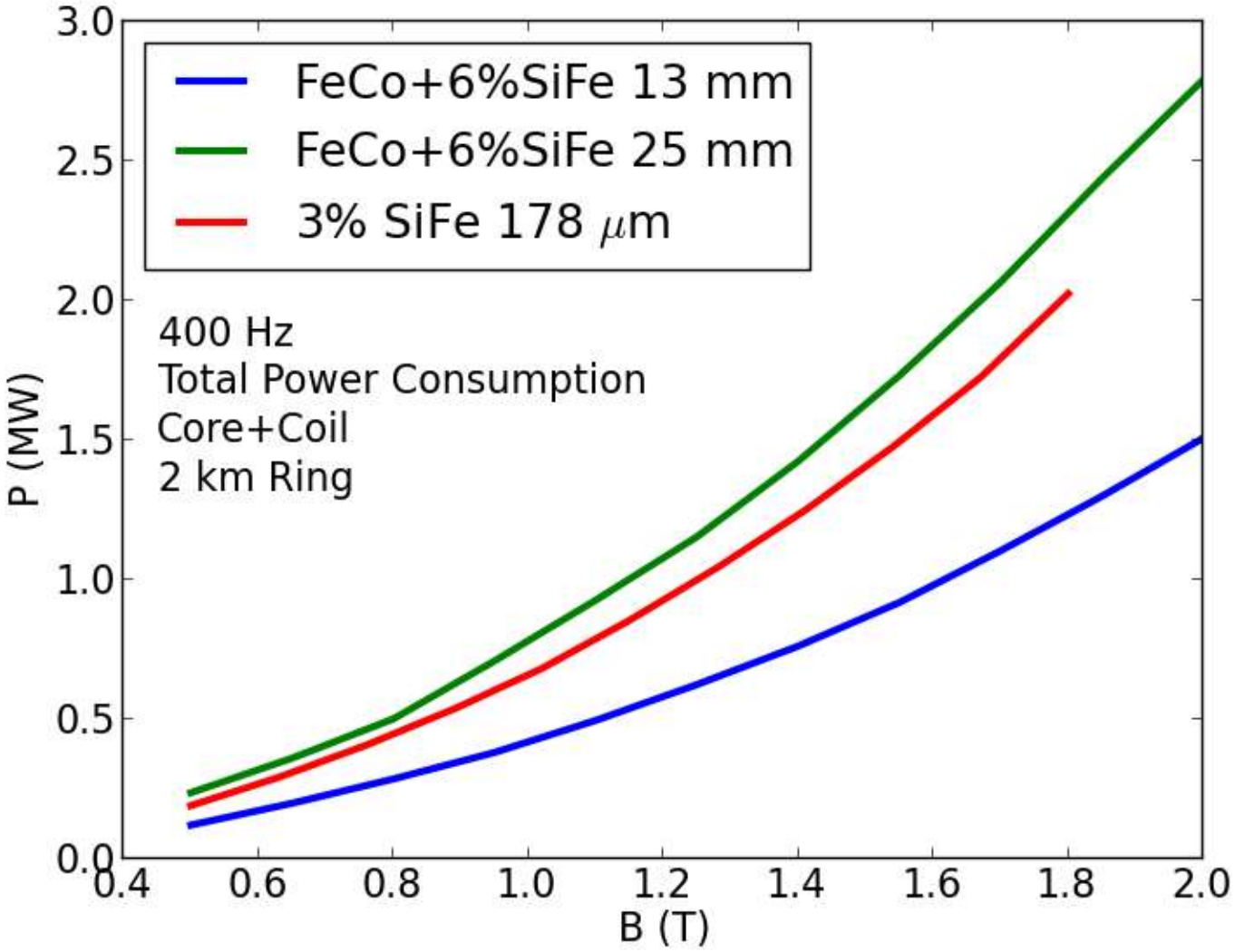
Coil

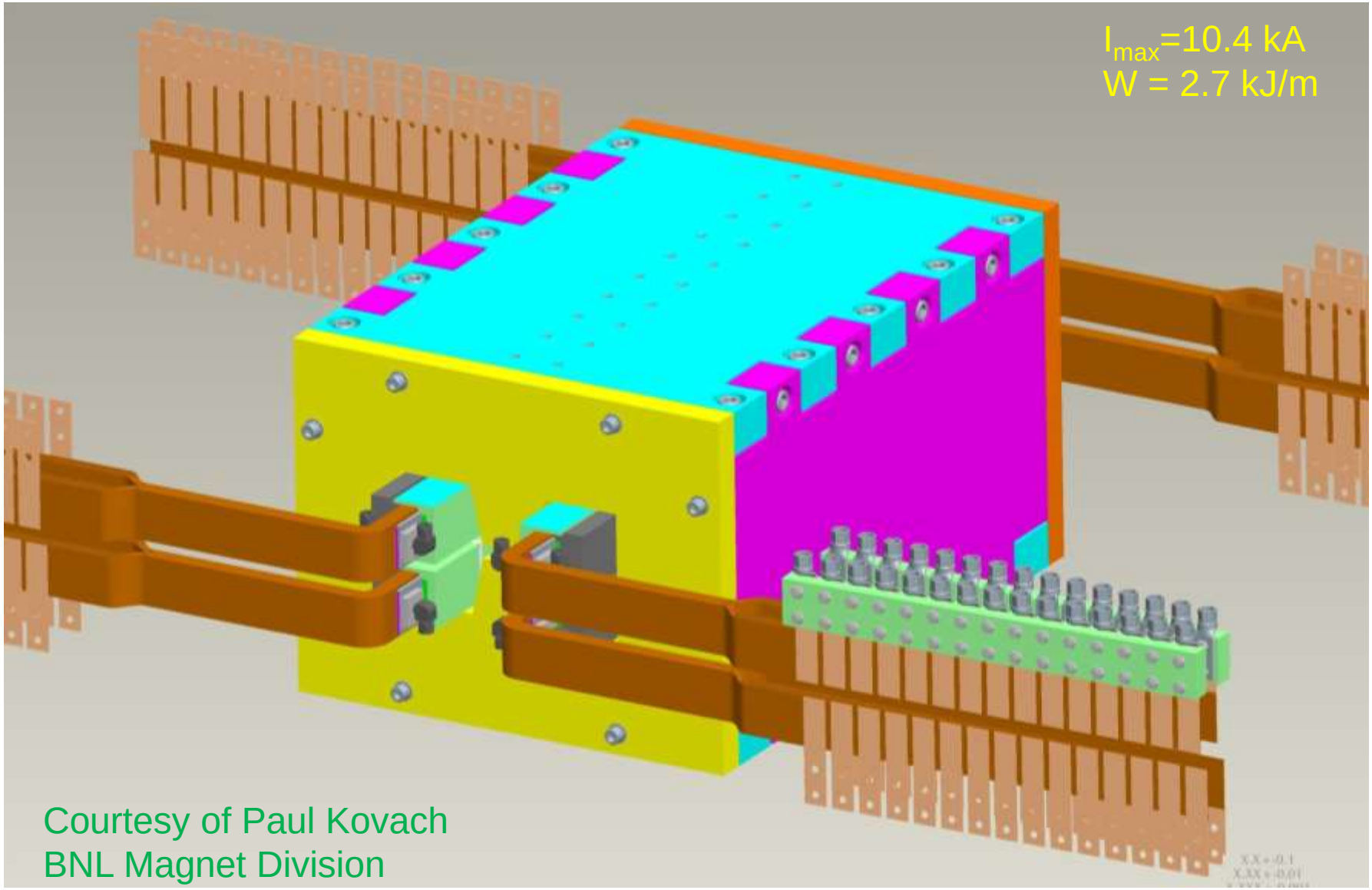
- Eddy current losses
  - Conductor shape
- Conductor geometry
  - Copper sheets
  - 80 mm wide, 1 mm thick
  - Insulation: 25 μm thick
- Coil position
  - Field leakage from yoke
  - Optimized to minimize dB/dt
- Losses: evaluated using FEA
  - 500 kW for all dipoles in ring (2T, 2 km length)
  - 400 Hz pulse, 15 pulses per second



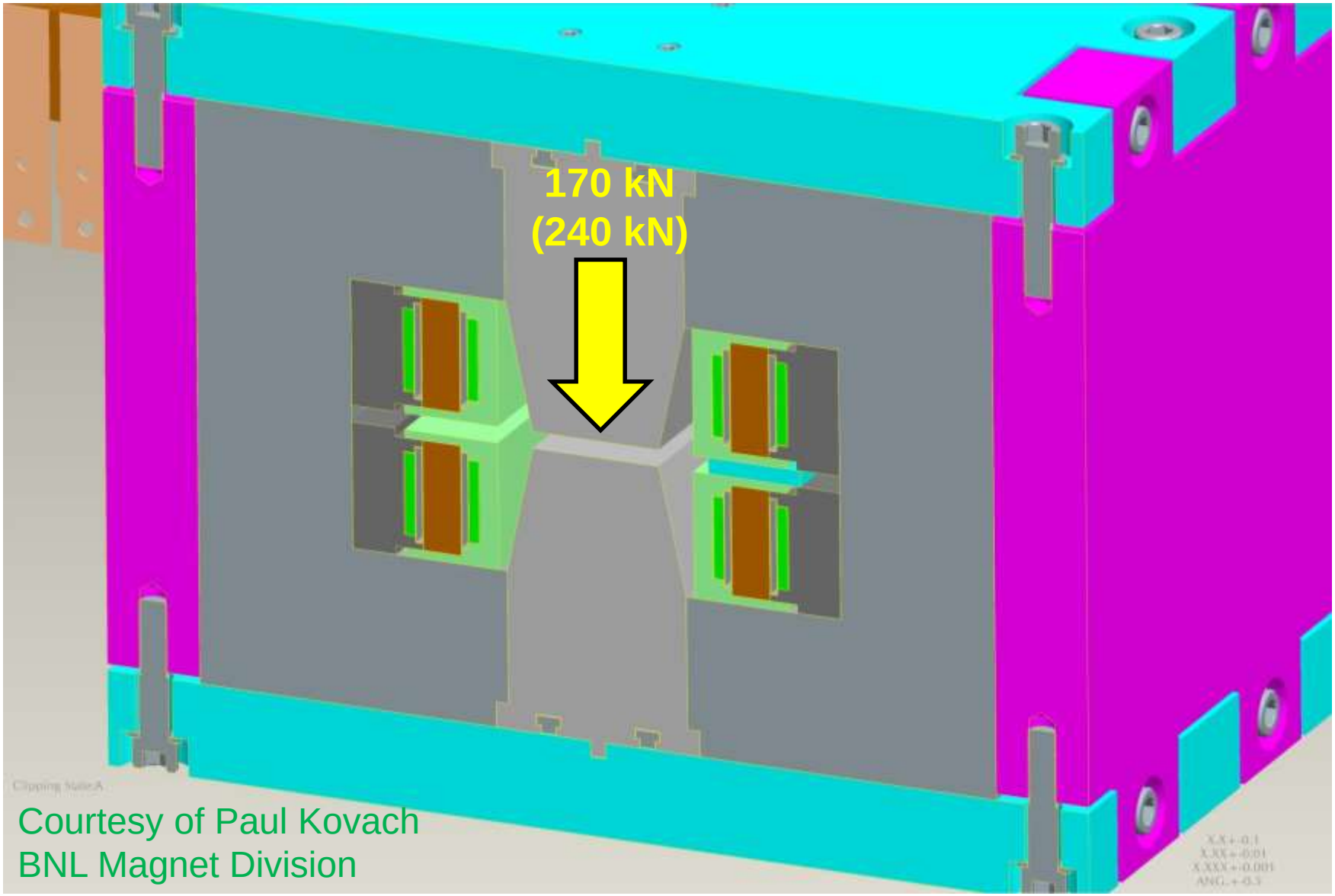
Total Power Loss



Engineering



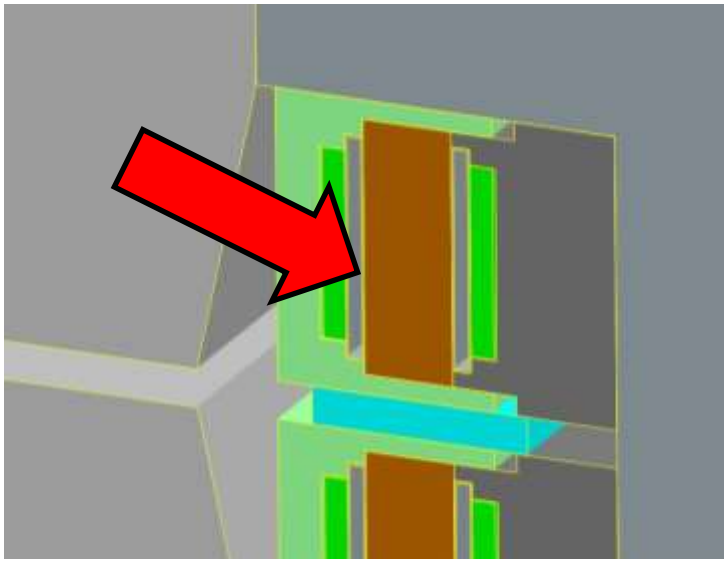
Engineering

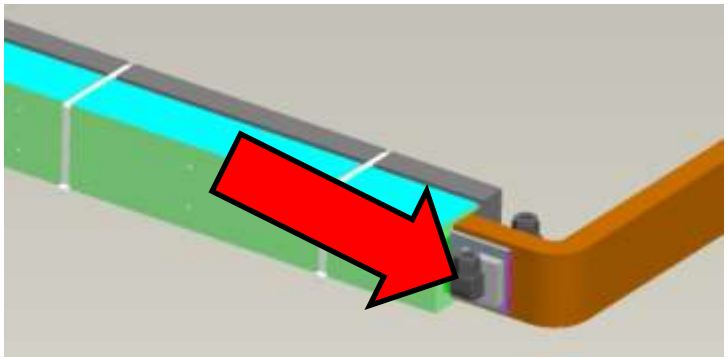


Courtesy of Paul Kovach
BNL Magnet Division

Cooling

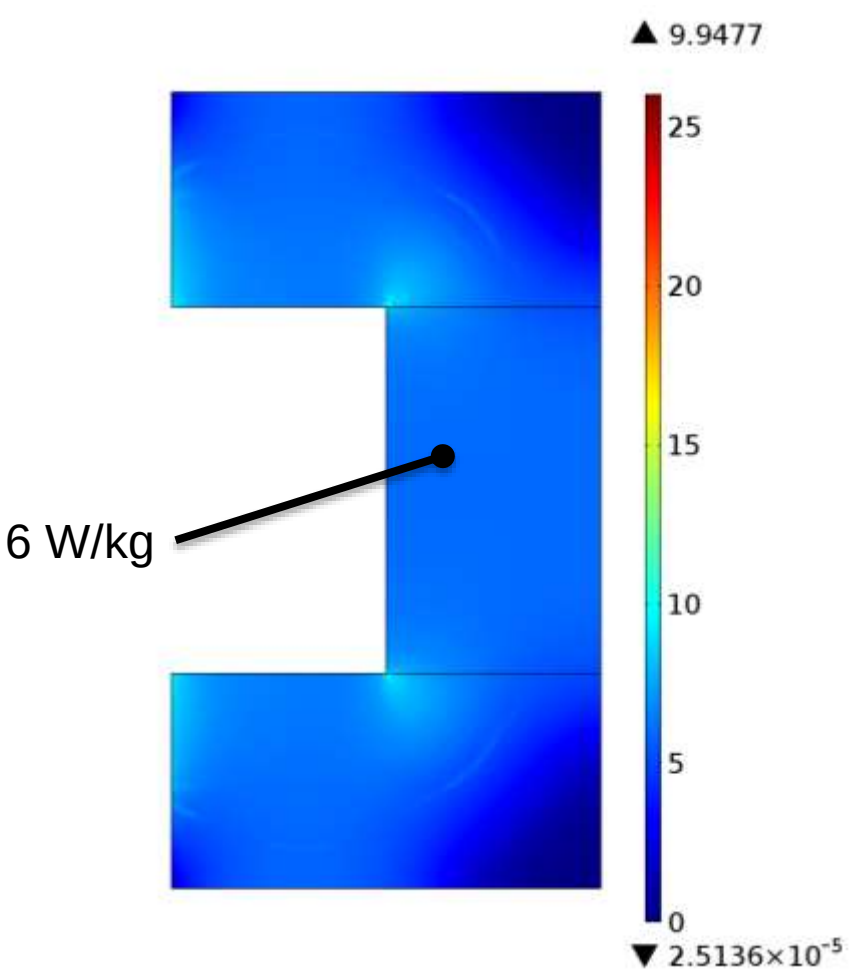
- Coil
  - 250 W/m in total (2T)
  - Cooling: outer faces
  - q < 0.1 l/s
- Finite element simulations
  - Temperature gradient: <2K



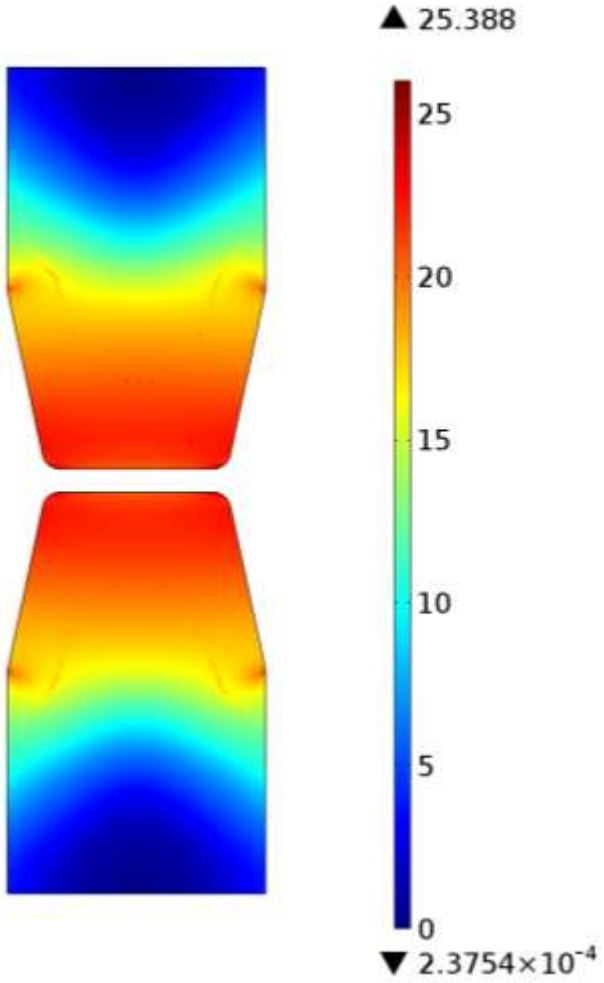


Cooling Yoke

Total average power dissipation: 500 W/m

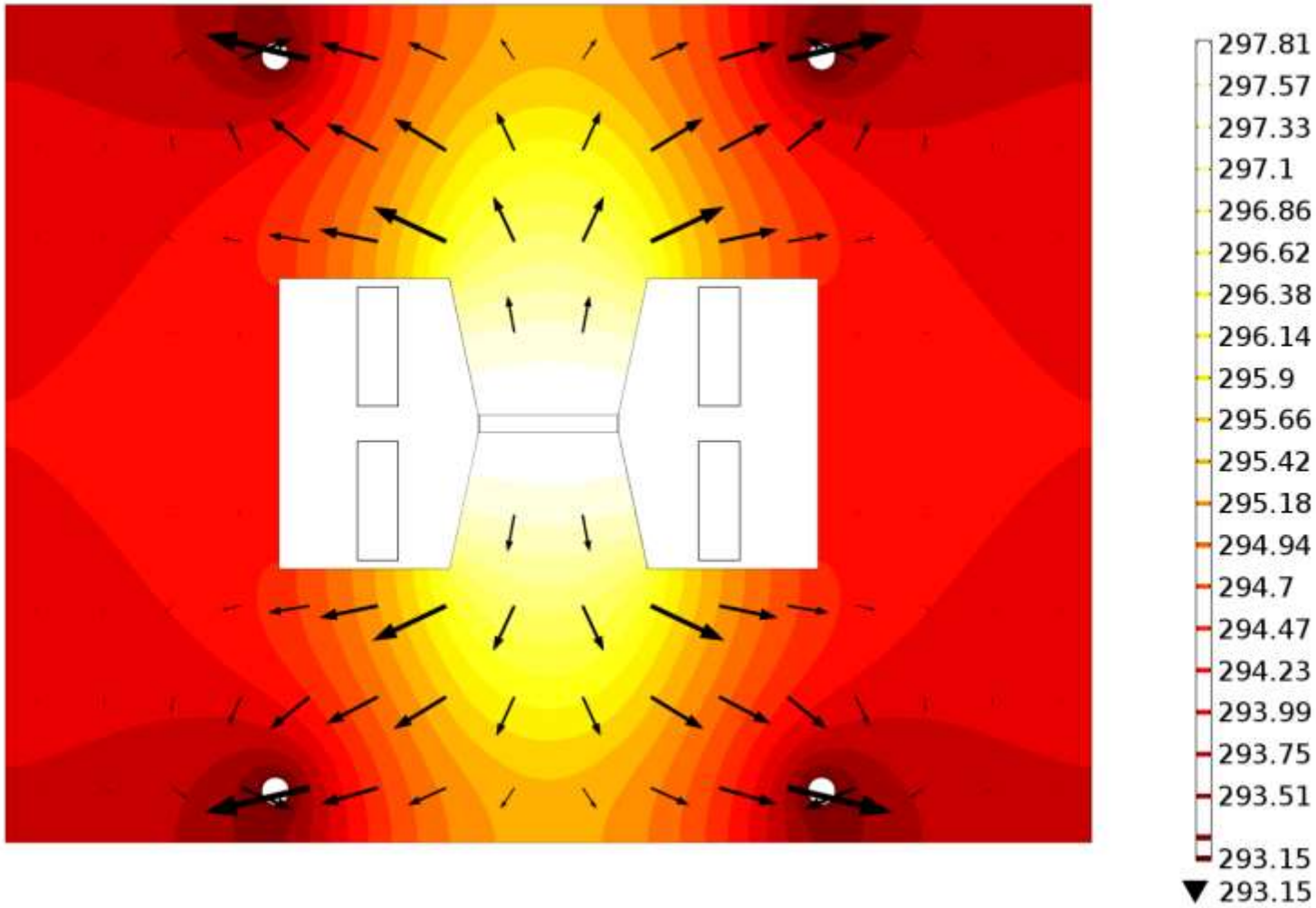


6.5%SiFe



FeCo

Heating Core



ΔT<5K

Conclusion

- Concept of dipole magnet
  - Combines strength of two materials
- Performance
  - Good field quality up to 2T
- Power losses
  - Acceptable losses at 400 Hz (2T: 1.5 MW for ring)
- Engineering concept
  - External clamp to deal with forces
  - Cooling seems manageable
- Planned: test magnet system
- Future work: activation studies

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