Network model for REBCO pancake coils with heat transfer

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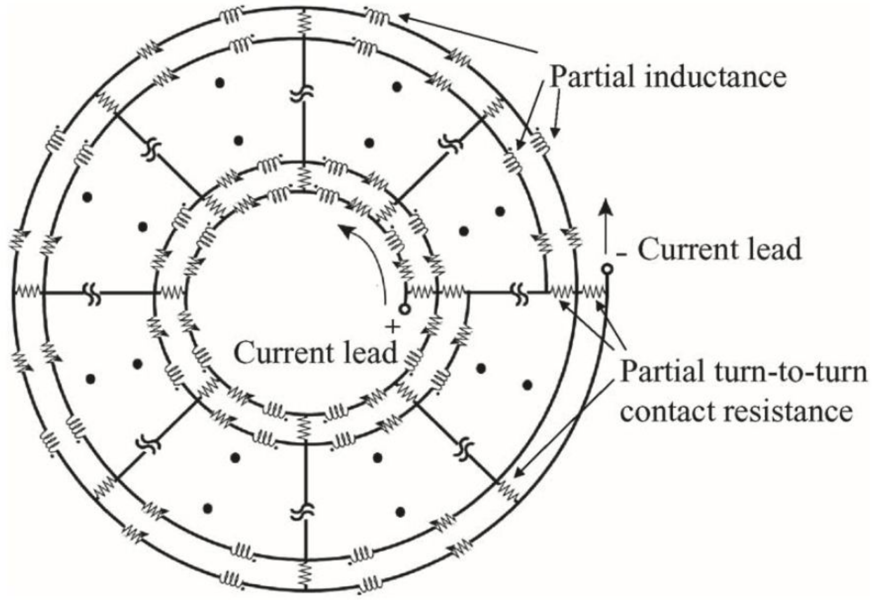
Roadmap

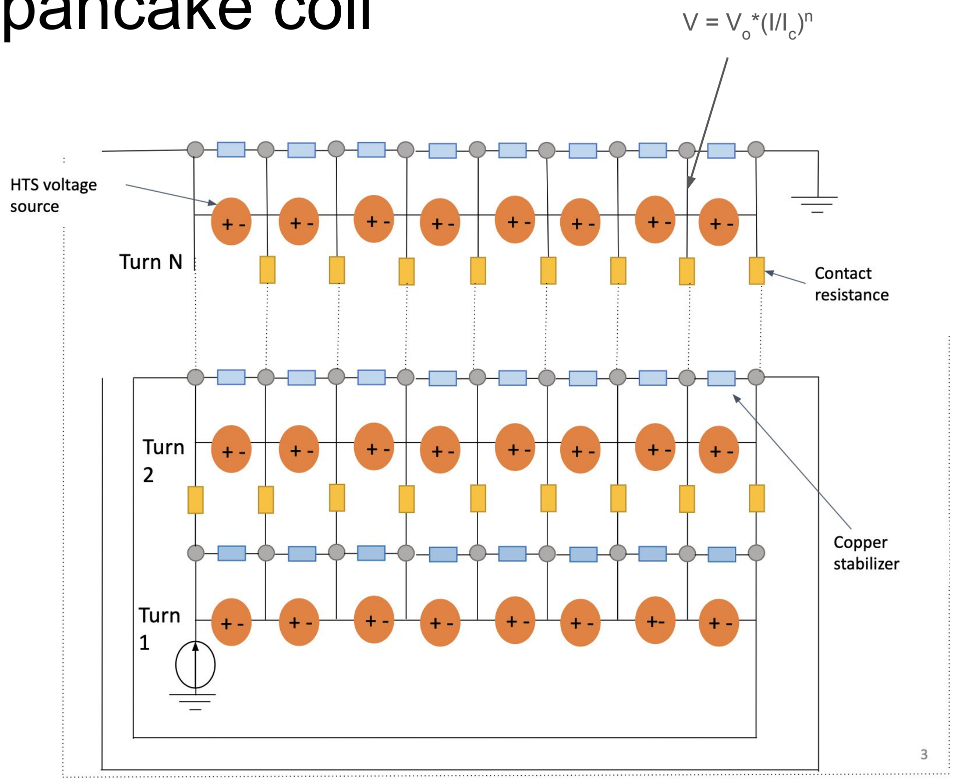
- Motivation
- Overview of modeling: circuit representation, modeling details, parameters
- Comparison to experimental results
- Preliminary insights on current sharing

Big picture

- Want to be able to study contact resistance in order to understand current sharing
- No-insulation technology a candidate, but we need to understand current sharing around defects + local hotspots
- These data are difficult to obtain experimentally; therefore, we want to develop a model that we can use to interpret contact-resistance technologies
- Driving question: How is current distributed around defects and local hotspots?

Network Model for a REBCO pancake coil





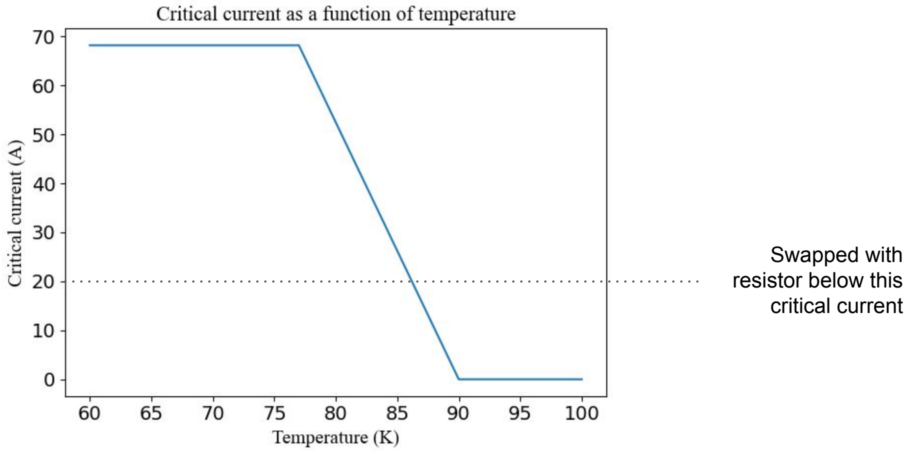
X. Wang et al., TAS 2015, DOI: 10.1109/TASC.2014.2365623

Electrical model

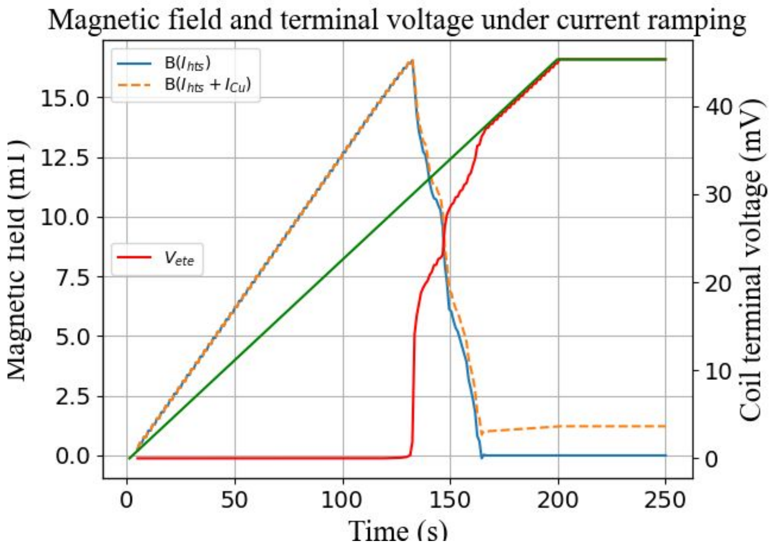
- Assumptions:
  - HTS modelled as voltage source; for $I_c \leq 20$ A, swap with $10^9\ \Omega$ resistor
  - Contact resistivity of $10^{-9}\ \Omega m^2$
- Inductors were not included in this version of network model (will be added in the future work)

Thermal model

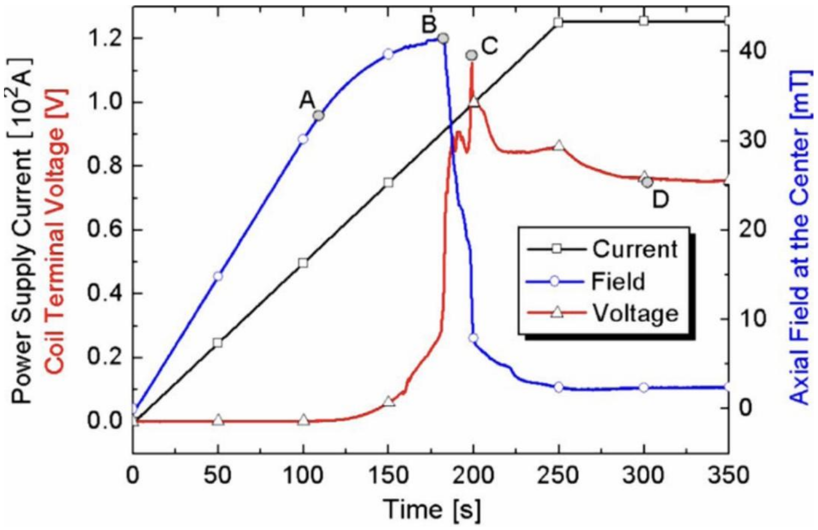
- Assumptions:
  - Adiabatic heating
  - Linear approximation of $I_c(T)$ and C(T)
  - Local temperature uniform across all layers of tape
    - Power contributions from each layer; volumetric average of temperature-dependent specific heat used
  - Finite difference approximation of 1D heat diffusion



Simulation results agree well with the experimental results (Hahn et al. 2011)

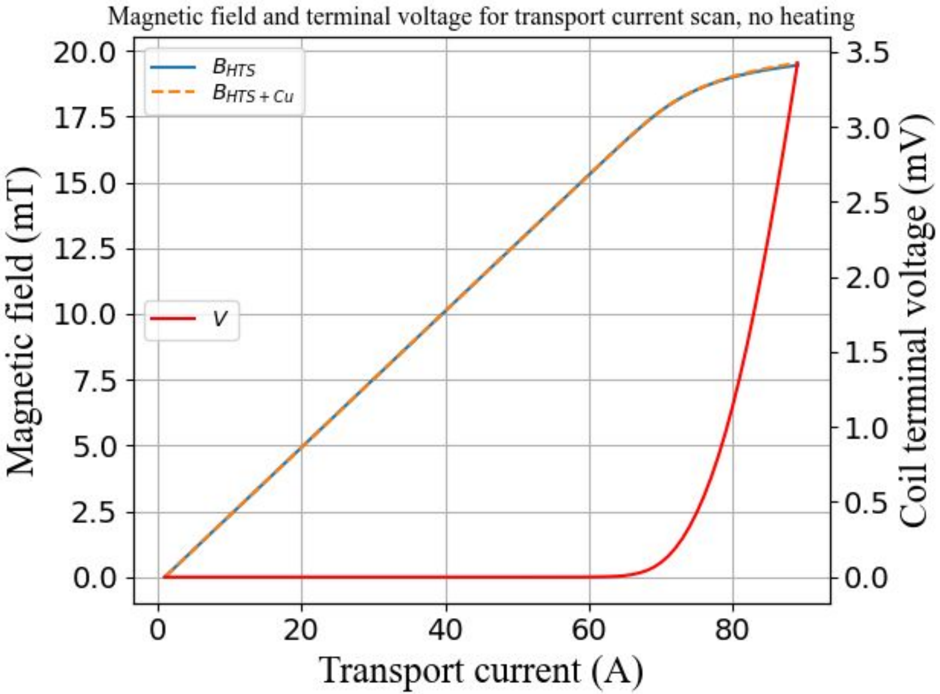


Simulation with operating current up to 100 A

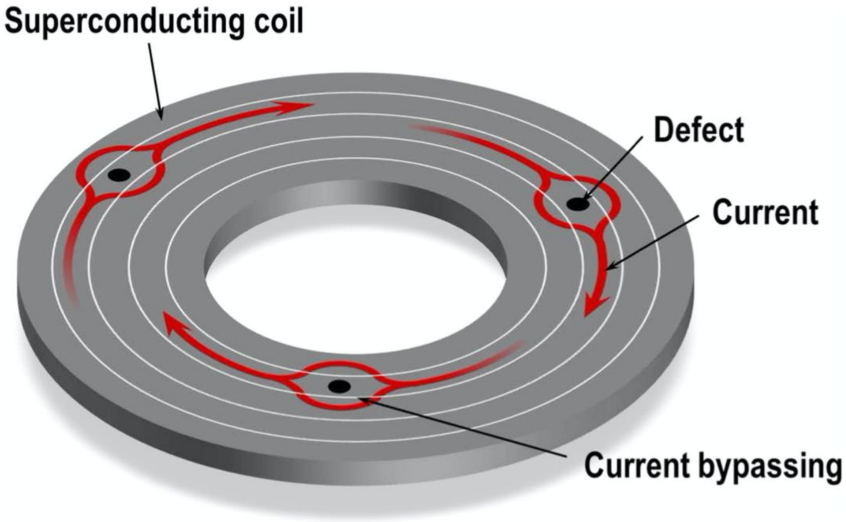


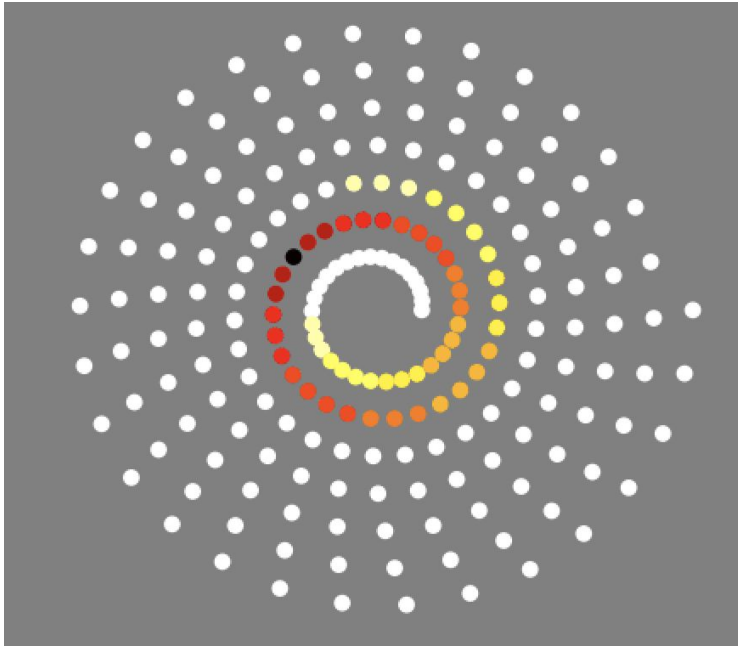
S. Hahn et al, IEEE TRANSACTIONS ON APPLIED SUPERCONDUCTIVITY, VOL. 21, NO. 3, JUNE 2011

In absence of heating, axial magnetic field in a no-insulation coil is saturated when transport current is higher than I_c



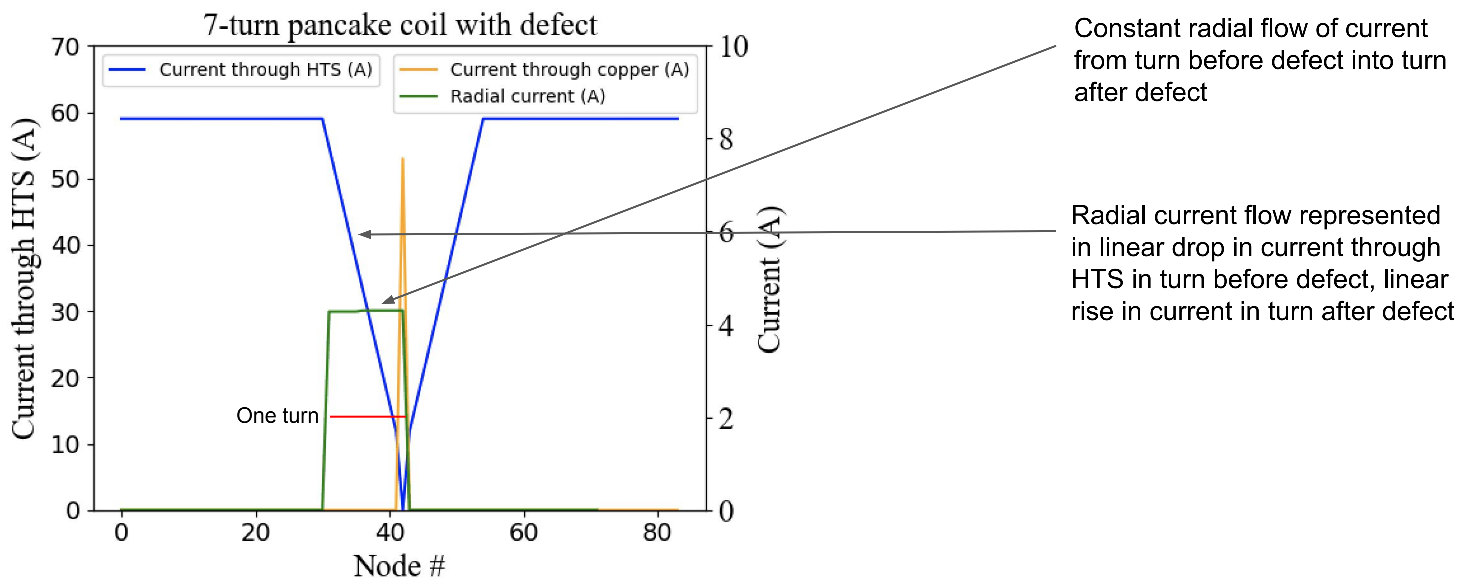
Insights: current sharing around defect different than assumed





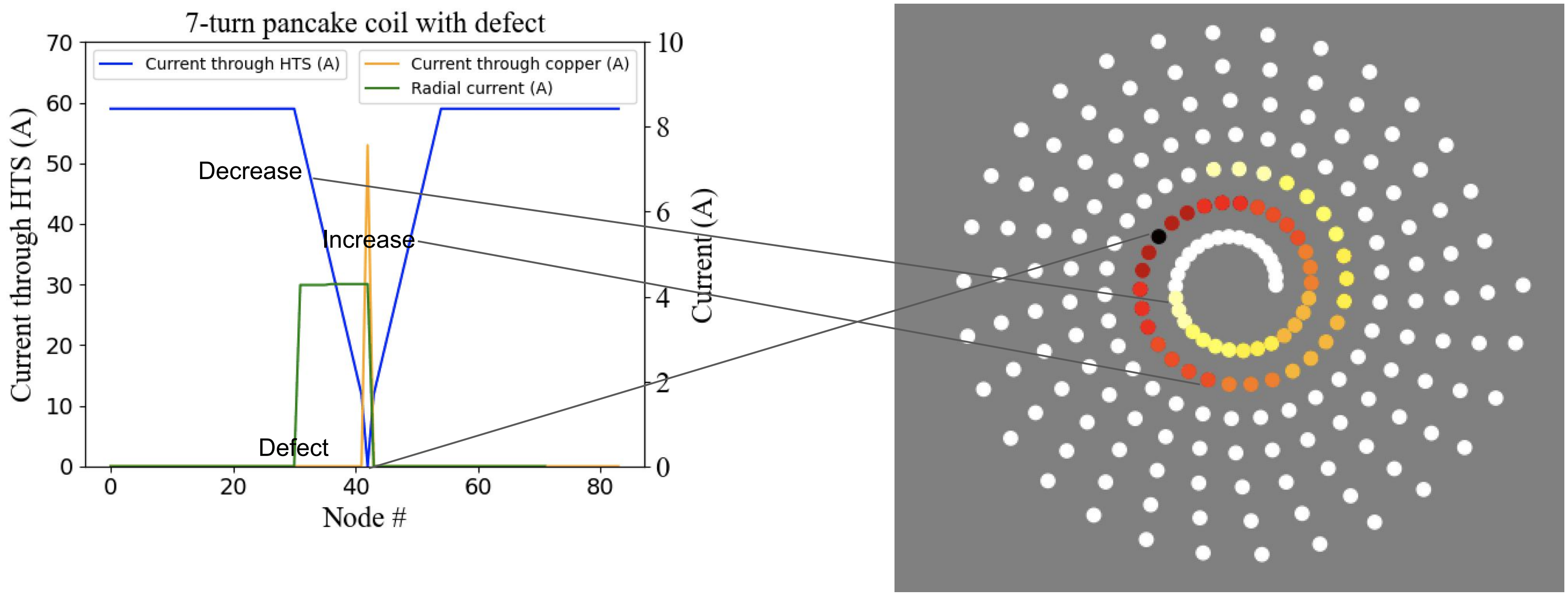
S.Hahn et al 2016 Supercond. Sci. Technol. 29,105017

Simulated current distribution in a no-insulation coil with one defect



Current in HTS starts to decrease linearly from transport current level one turn before the defect, and increase linearly afterwards. It reaches the transport current level one turn after the defect spot.

Simulated current distribution in a no-insulation coil with one defect



Current in HTS starts to decrease linearly from transport current level one turn before the defect, and increase linearly afterwards. It reaches the transport current level one turn after the defect spot.

Recap

- Model reproduces general behavior of V, B
  - Can be improved by specifying thermal boundary conditions
- Magnetic field saturation due to radial current flow
- Current around a defect takes a longer length of tape to recover