ecoswing

Self-heating effect in HTS coils

MT25, 28-08-2017

Marc Dhallé[1], Anne Bergen[1], Erik Krooshoop[1], Herman Ten Kate[2], Konstantyn Yagotyntsev[1], Marcel ter Brake[1], Markus Bauer[3], Martin Keller[3], Nir Tzabar[1], Sander Wessel[1]

[1)] University of Twente [2)] CERN [3)] THEVA

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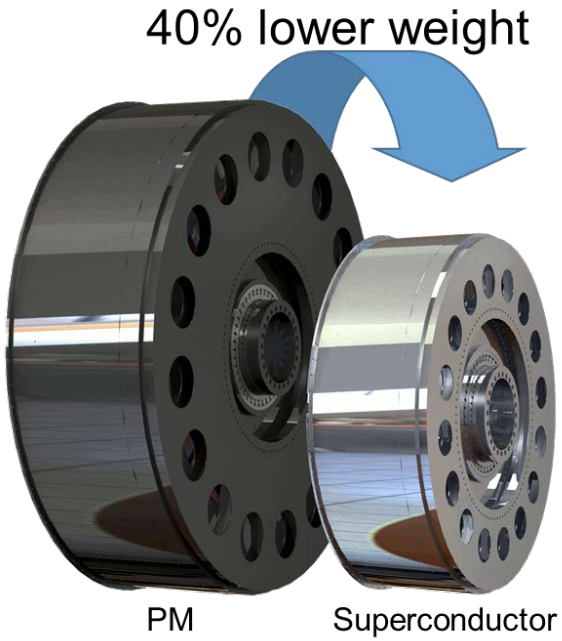
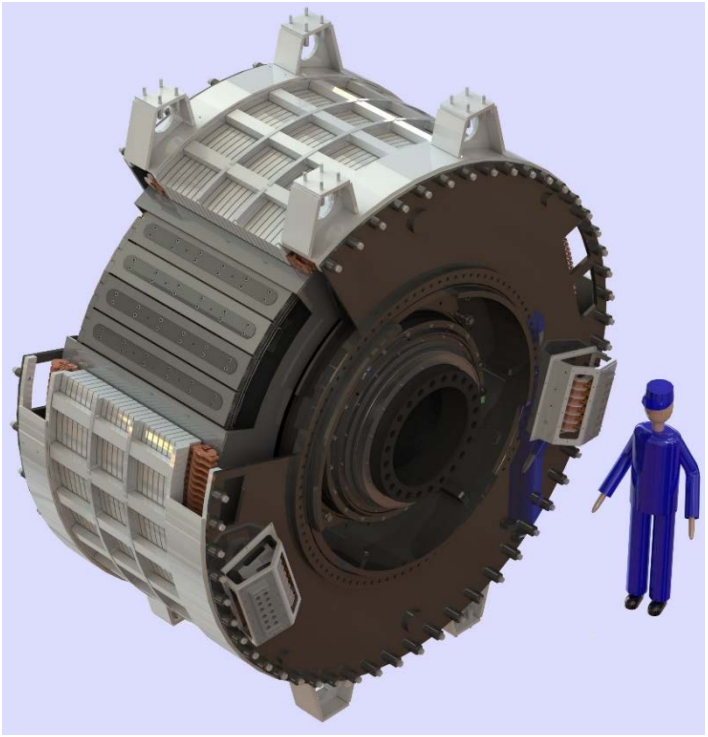
Introduction

EcoSwing *"… aims at demonstrating world's first superconducting low-cost and lightweight wind drivetrain on a large-scale wind turbine"*





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Plenary session by Jürgen Kellers, Thursday 31th August, Auditorium 16:00-16:40

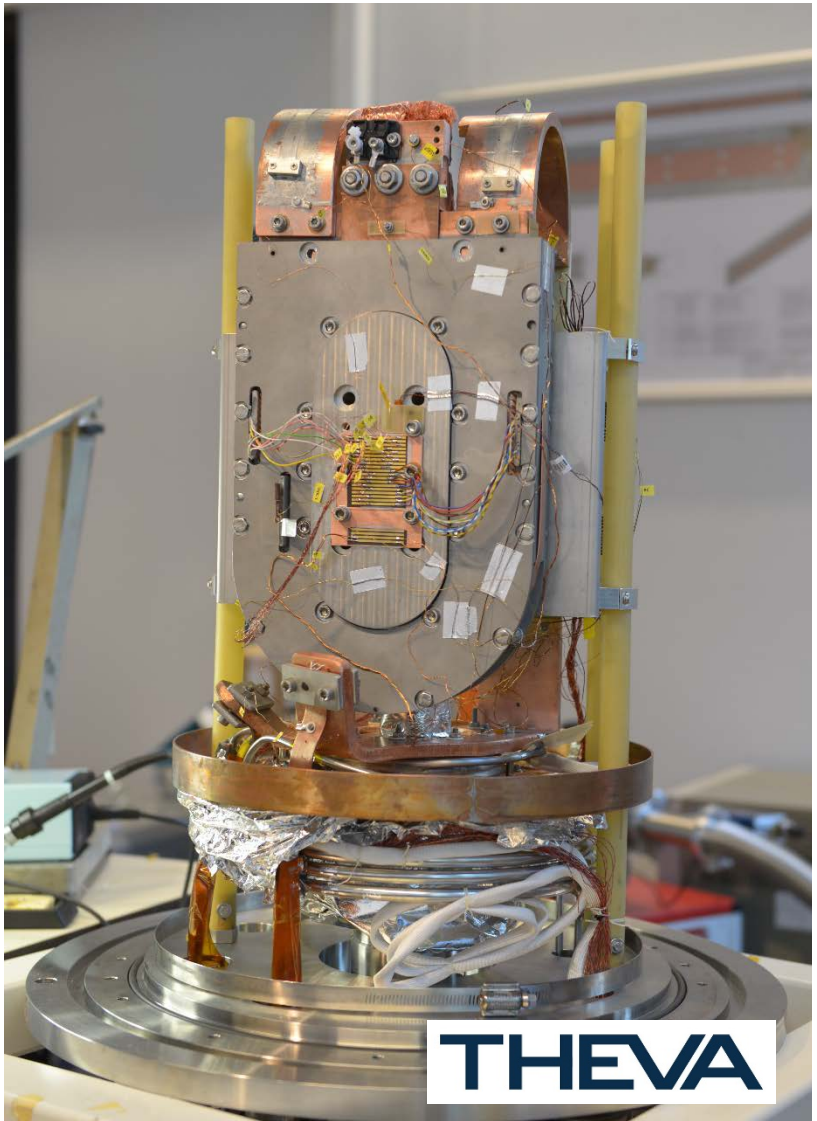
Introduction

Sub-scale HTS test-coil

Mounted in a vacuum chamber with a 2-stage cryocooler

In order to

- Validate the superconducting behavior of the pole assembly
- Characterize the electrical circuit and interconnects
- Verify the thermal housekeeping



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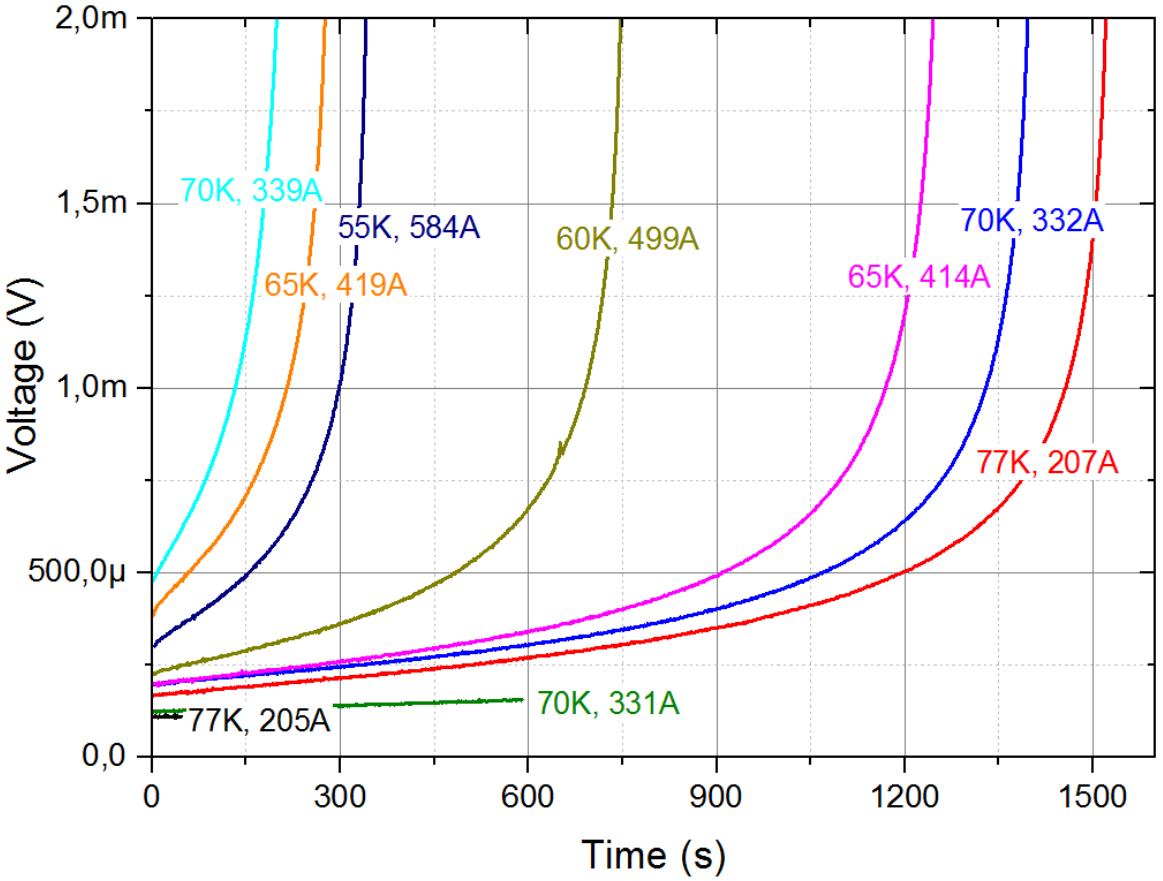
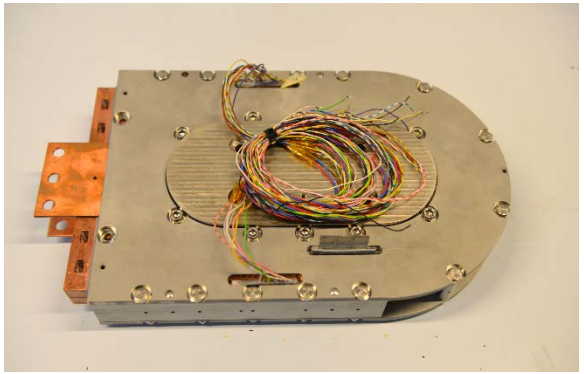
Introduction



Measurements at constant current:

- Small change in current has significant effects on the voltage development
- All curves have similar shape

→ Development of thermal model



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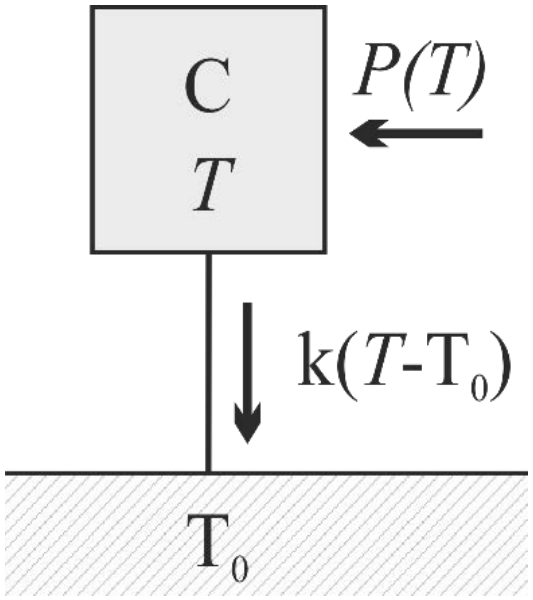
Analytical model

Model the coil as a single thermal mass connected to a thermal bath

$$C\frac{\partial T}{\partial t} = P(T) - k(T - T_0)$$



Combine with the non-linear self-heating term of a superconductor

$$P(T) = I_0 V(T) = I_0 V_c \left(\frac{I_0}{I_c(T)}\right)^n$$

Leads to a non-linear temperature vs. time expression

$$\frac{\partial \theta}{\partial \tau} = \frac{1}{(1-\theta)^n} - \alpha\theta$$

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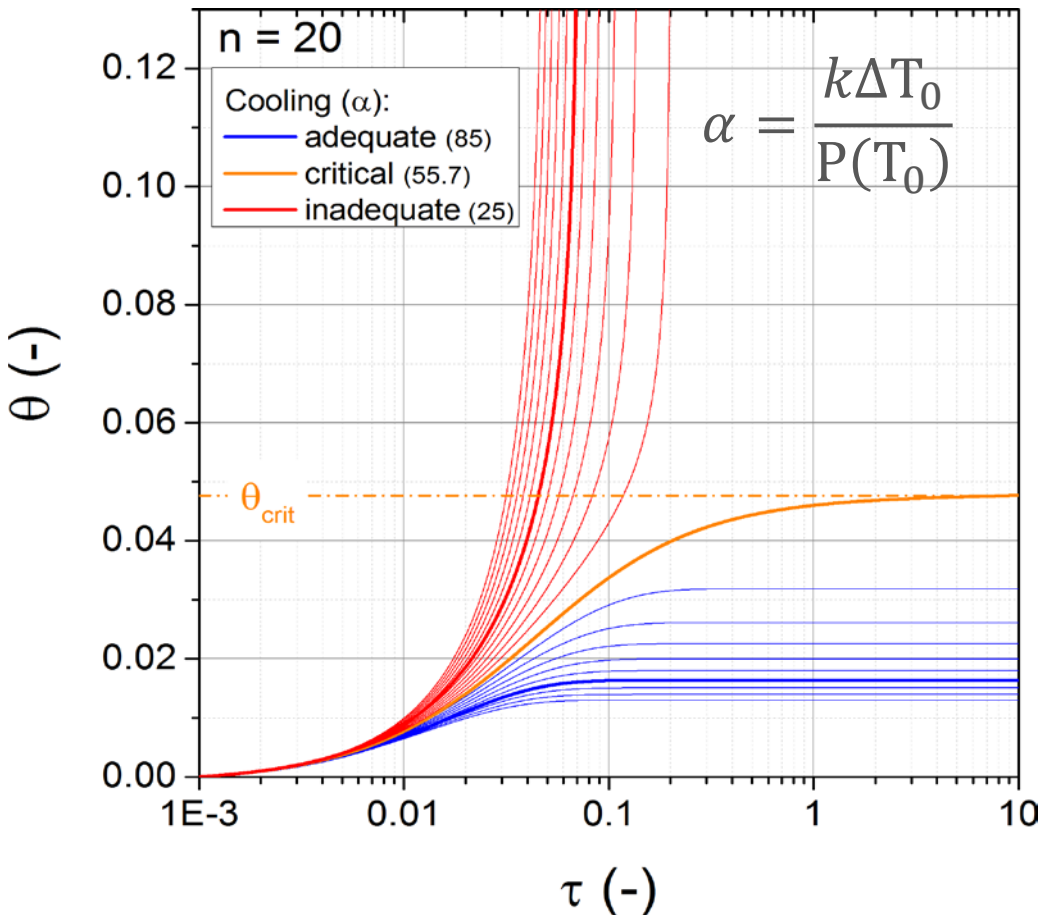
Analytical model



Shows two sharply separated families

- Adequate cooling
- Inadequate cooling

Upper limit that leads to a stable temperature

$$P(T_0) \leq \frac{k\Delta T_0}{2.8n}$$

Heat capacity does not play a role whether a stable temperature is reached, but determines the time scale

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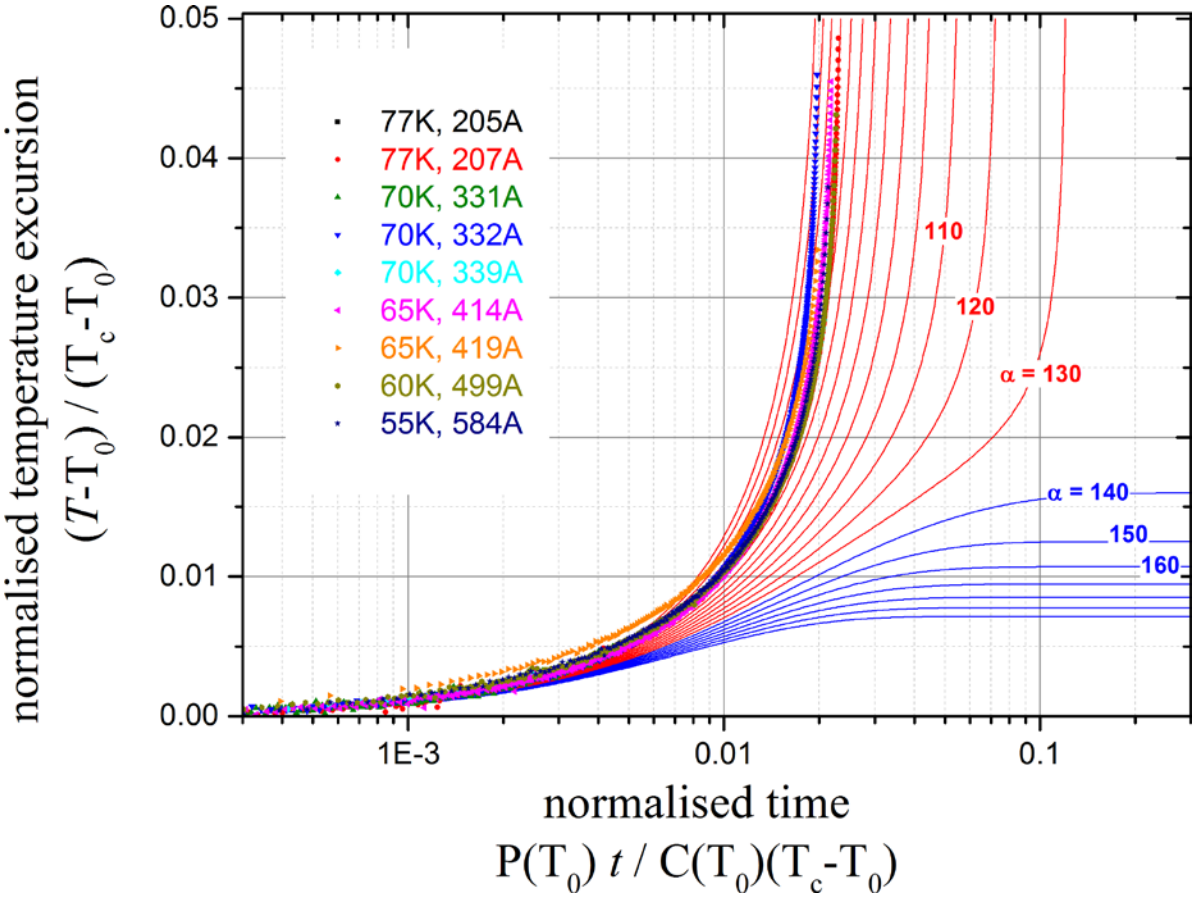
Comparison test-coil

Relatively good agreement with results of sub-scale test-coil



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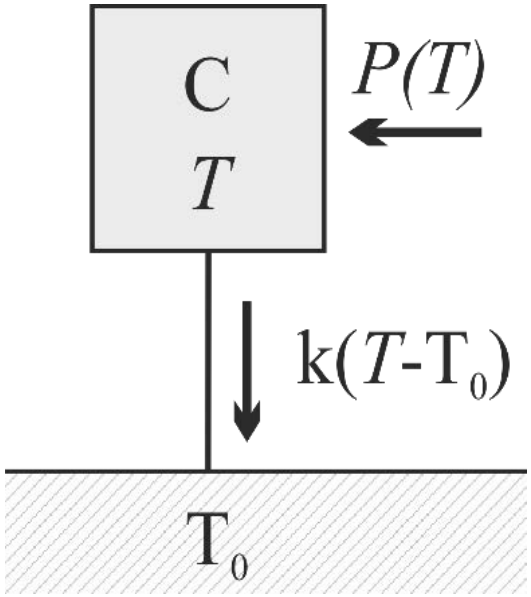
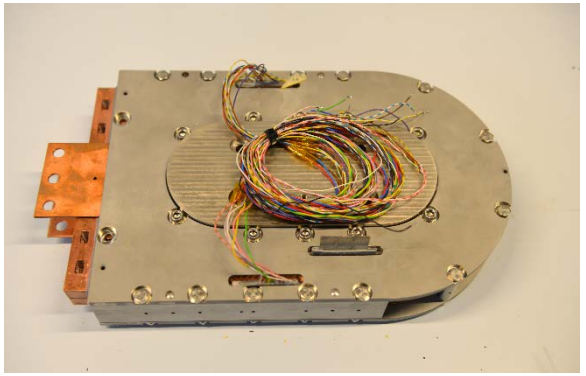
- **Single-tape behaviour?**
- Discussion





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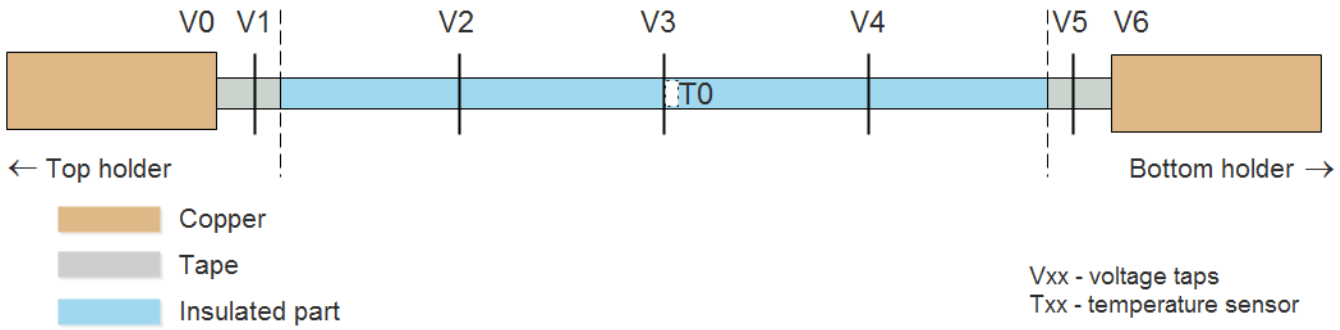
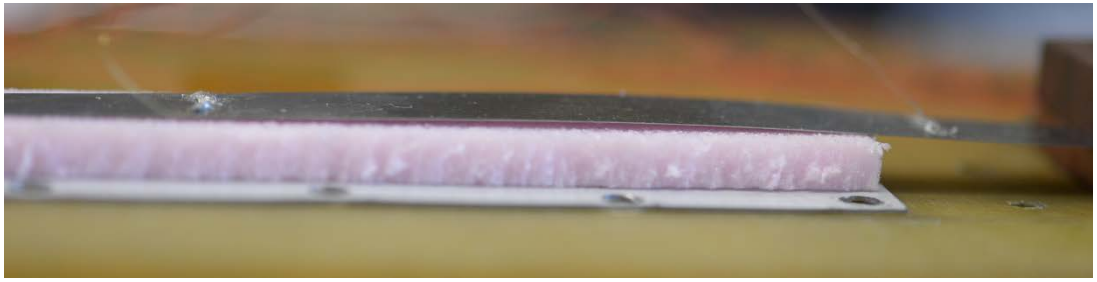
HTS tape setup

Sandwich a single HTS tape between two foam pieces & submerge in L N_2

- Instrument with various voltage taps and temperature sensor(s)





→ Can we observe the same behaviour as was measured for the sub-scale test-coils?

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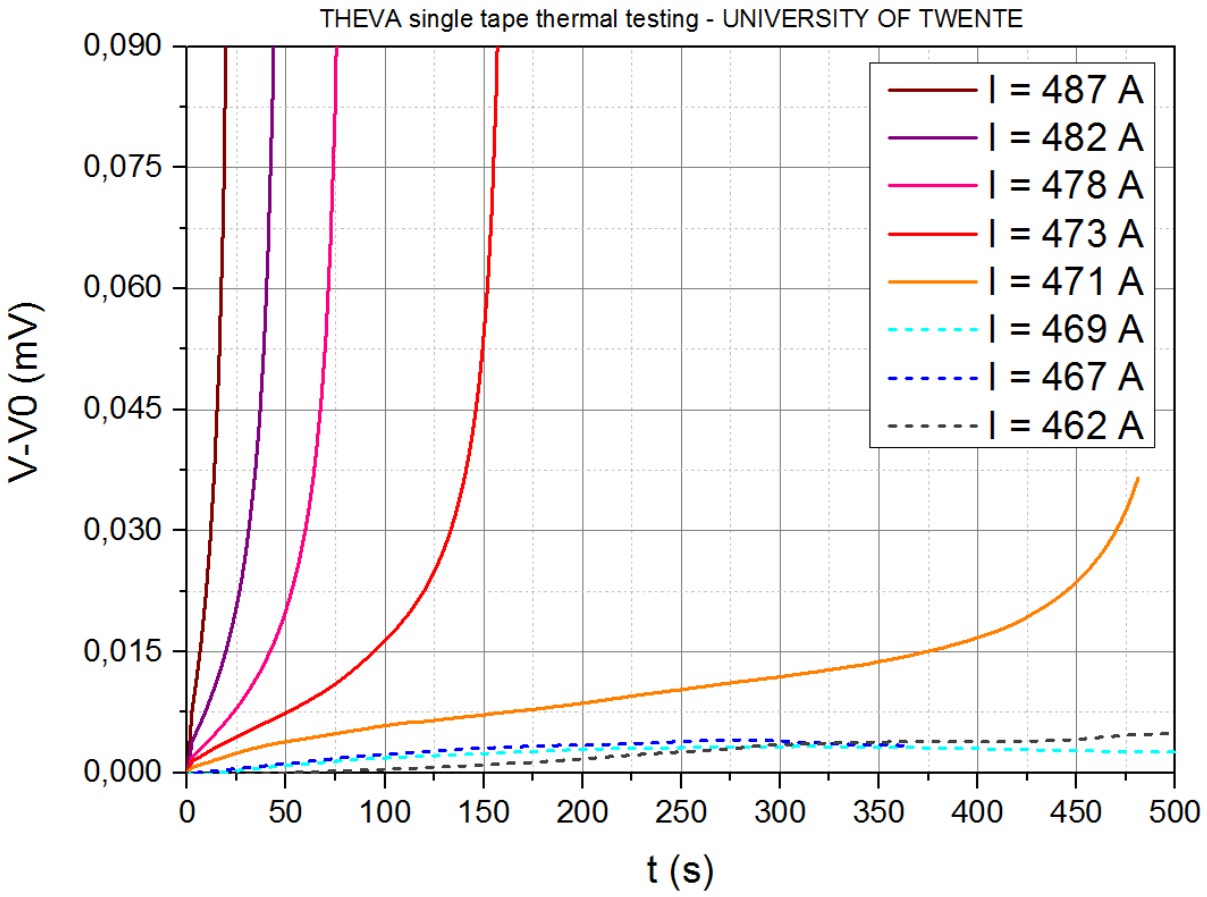
HTS tape setup



Similar observed behavior

Two families, either:

- Stable
- Unstable

Small change in current have significant effects on the voltage development

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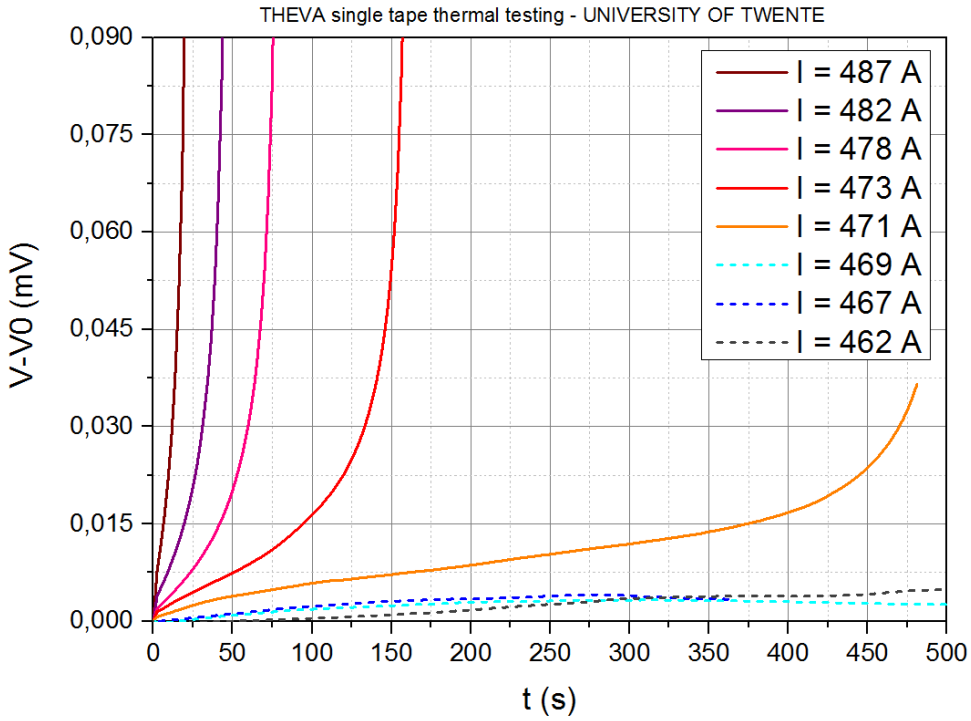
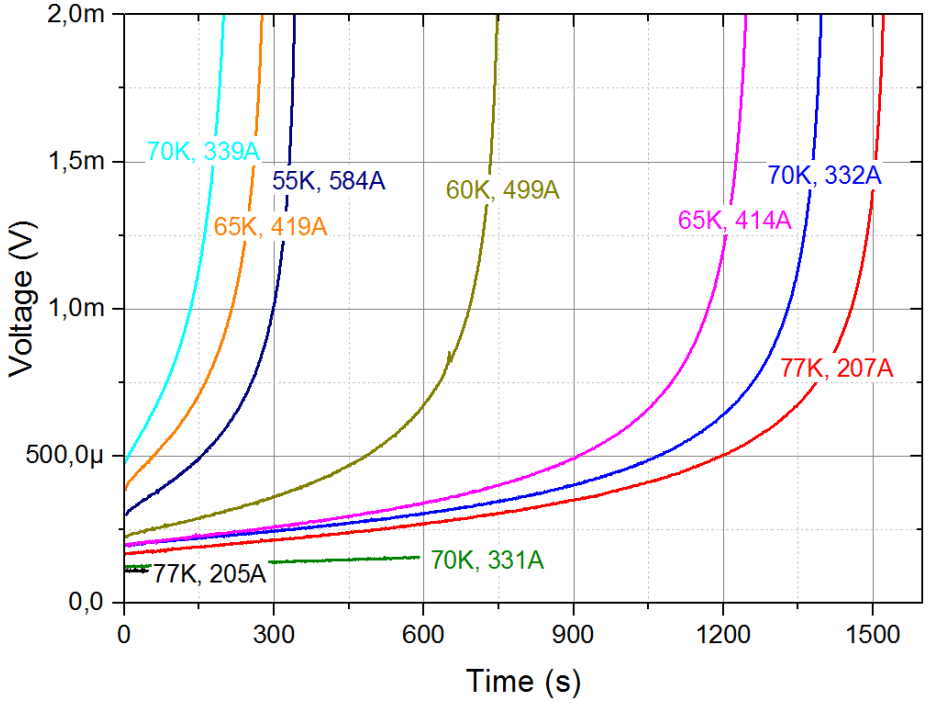
Comparison model, coil





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→ single tapes can be used to validate the model!

Discussion/conclusion

- Relatively good agreement between model and coil results
- Use single-tape setup to validate model further

- Future experiments
  - Add ‘weak spot’
  - Different insulating materials

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Questions…?

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