T. Winkler, GSI

I.FAST Period 2 Review, 15.07.2024

WP/Task structure and objectives

- Design Parameters for a round, high current, low ac loss HTS ReBCO cable
- Application: fast ramped, high field accelerator magnets
- Milestone: M24 measurements on lab-scale cables
- Deliverable: M32 Report on cable parameters
- Members:
  - Institute of Electrical Engineering (IEE), Slovak Academy of Sciences, Slovakia
  - ILK Dresden, Germany
  - GSI, Germany
  - EMS Chair, University of Twente (UT), Netherlands

Deliverables and Milestones P2

- Milestone: M24
  - HTS Nuclotron Cable Produced
  - https://doi.org/10.5281/zenodo.7995185

- Deliverable: M32
  - Fast-cycling Nuclotron HTS cable design https://doi.org/10.5281/zenodo.10697495

AC loss

From last years meeting:

$$Q_{hT} = \frac{2}{\pi cos\alpha} B_{max} I_c w$$

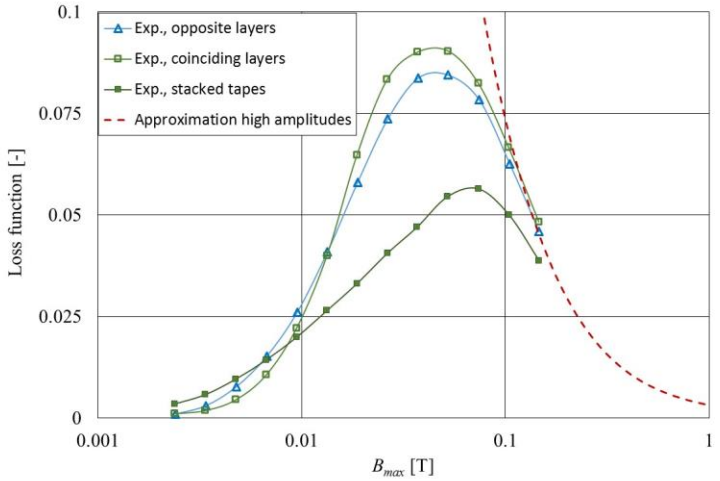
AC loss for a ramp from 1.9 T to 7.5 T:

373 W/m

Extending the ramp from 1 sec to 10 sec and introducing 0.5 mm wide filaments:

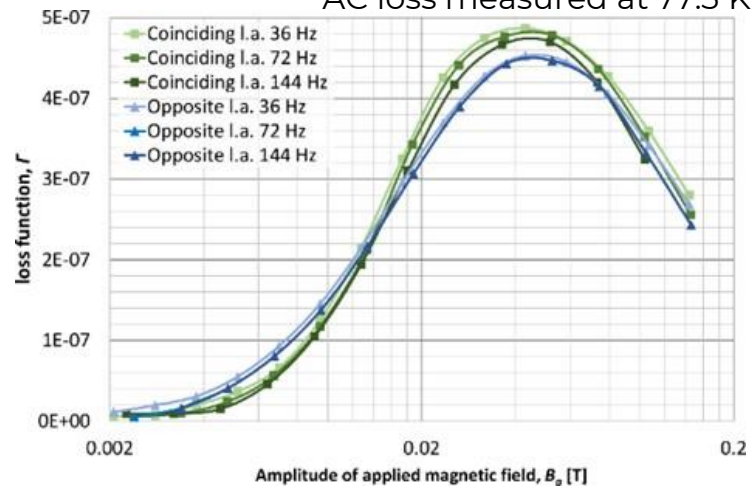
4.6 W/m

factor of **80** reduction



$$\Gamma = \frac{Q_{cable}}{L_{cable} S_{cable}} \frac{2\mu_0}{B_{max}^2}$$

AC loss measured at 77.3 K

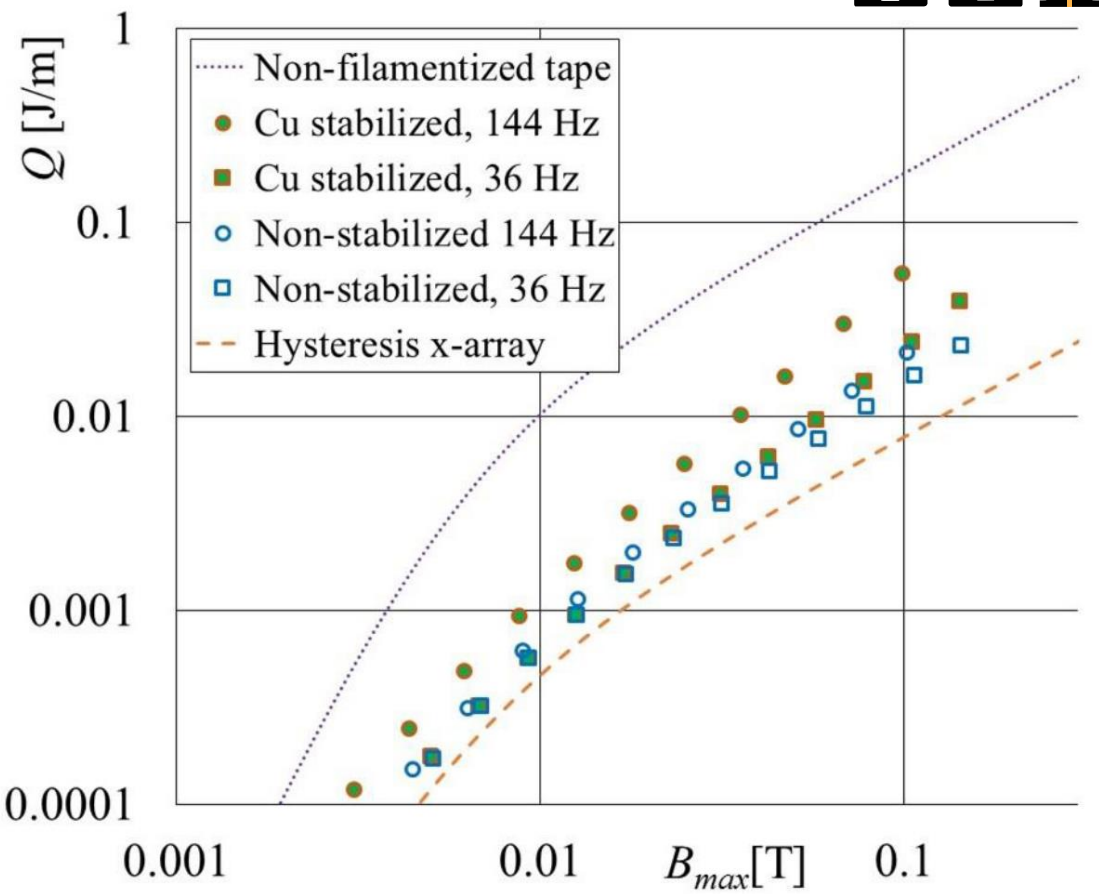


no frequency dependence
=> no coupling currents

AC loss – tape striation

Sample:
- 230 mm length, 10 mm former diameter,
- 12 mm wide tape with 19 filaments
- wf = 0.5 mm wide, gaps of wg = 0.1 mm
- lay angle α = 67 degrees

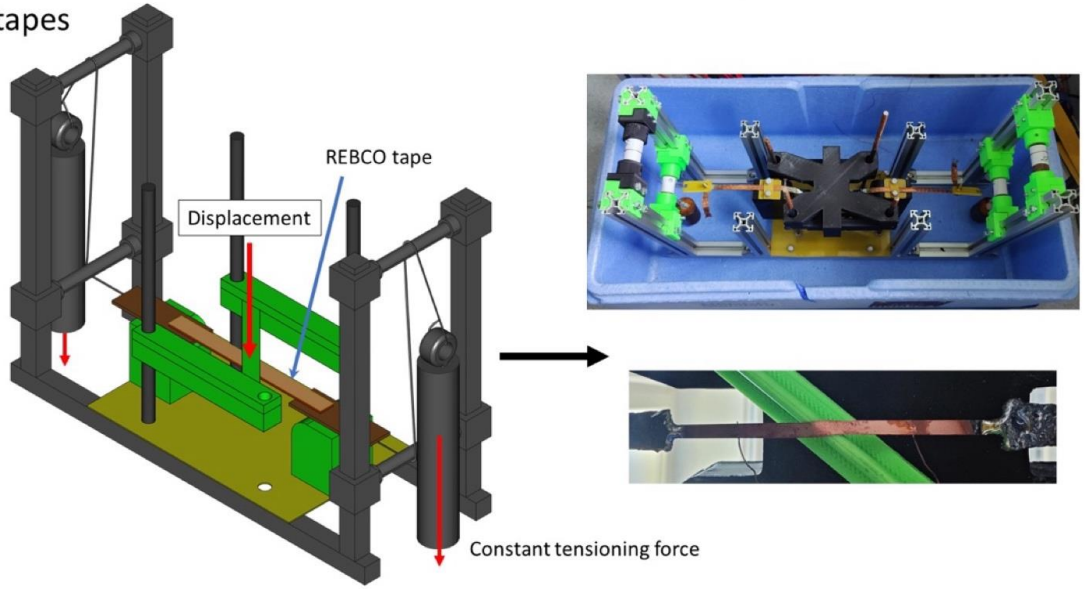
Additional coupling loss for the Cu stabilized sample

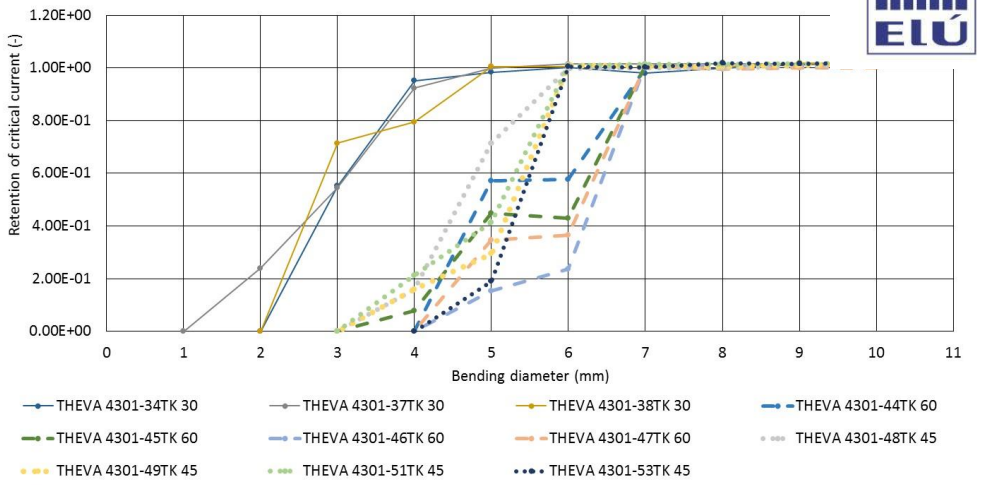


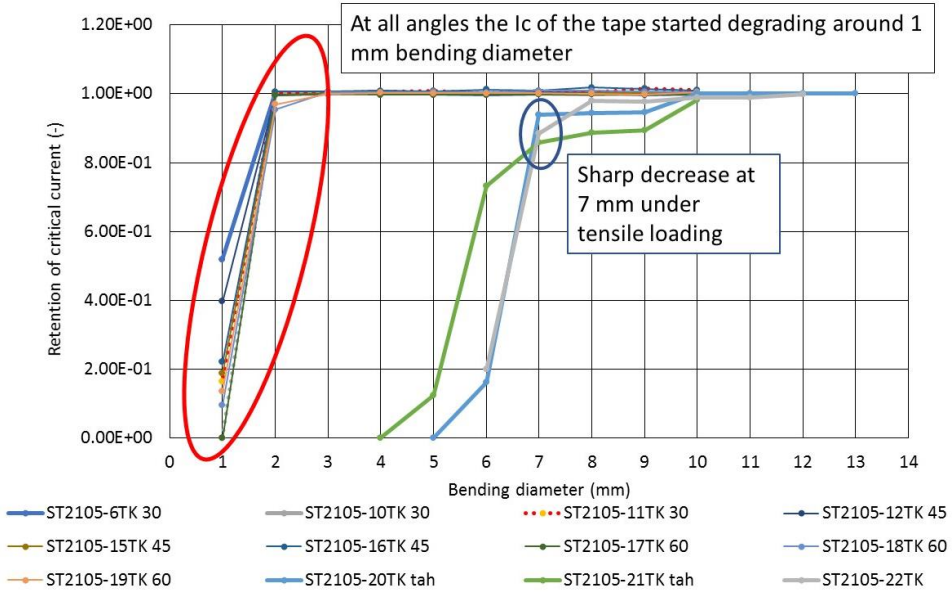
https://doi.org/10.1109/TASC.2024.3364133

HTS tape mechanics

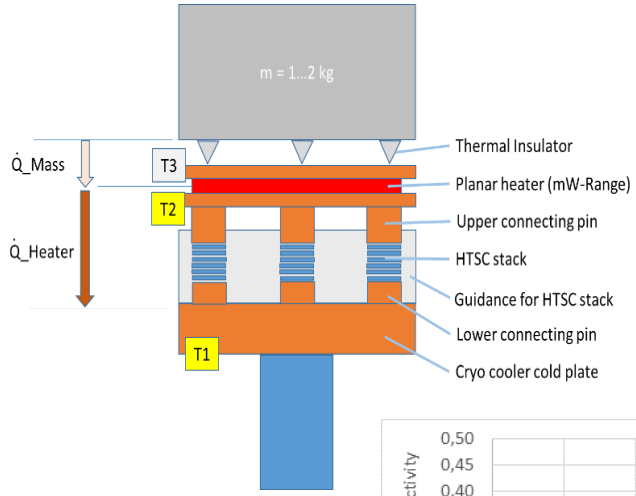
Measurement method for characterization of bending limits of HTS REBCO tapes

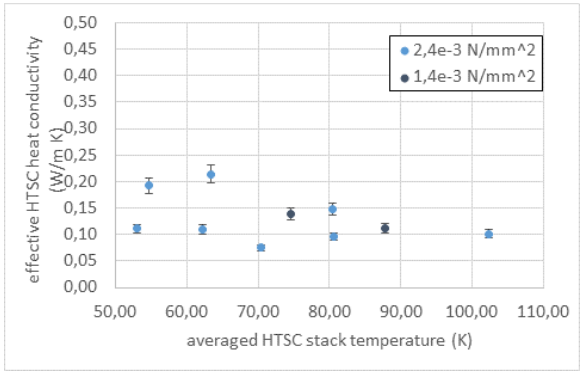




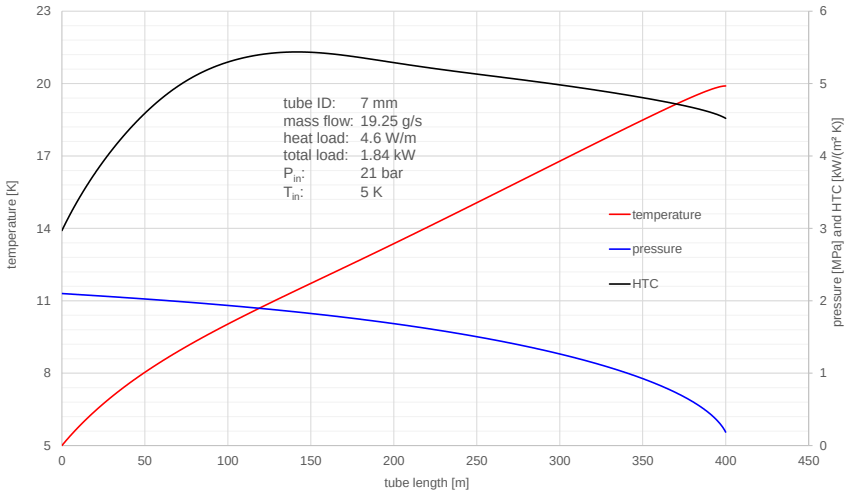


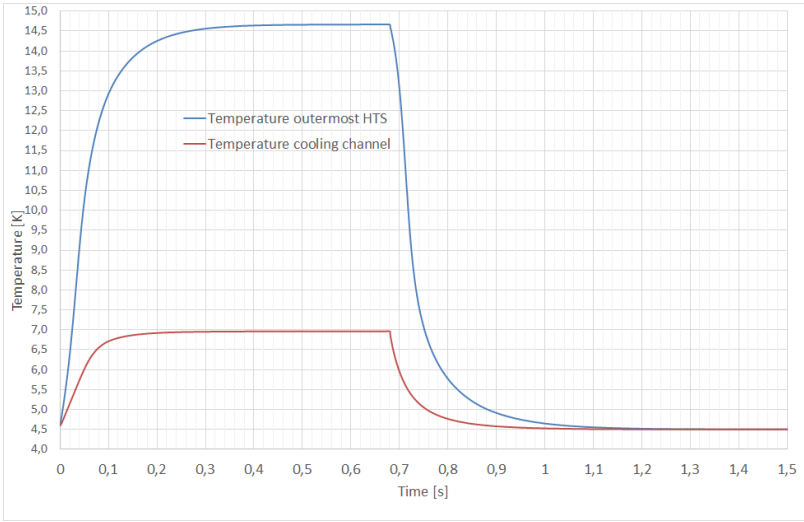
Thermal Conductivity Measurements





Simulation accounts for:
- heat transfer coefficient He to pipe wall,
- ”effective” thermal conductivity of tape stack





Experimental result:
heat conductivity plotted over the averaged HTSC stack temperature

Effective thermal conductivity for 25 tapes

Radial temperature for a short cable piece
Heat load 27 W/m

Relevance of objectives and impact

Fast ramped high field magnets are very challenging due to high AC loss and high forces

HTS materials enable a magnet design

- with higher coolant temperatures resulting in lower operating costs and energy savings.
- with higher magnetic field strengths resulting in compact machines.
- Striation is an enabling technology for HTS in fast ramped applications.

Hollow round HTS cables are suitable for these objectives due to their mechanical stability and the inner cooling channel.

iFAST

Thank you for your attention!

This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under GA No 101004730.