FCC week 2018

Study on Cryogenic Properties of SC Thin Films on Substrate

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EASITrain – European Advanced Superconductivity Innovation and Training. This Marie Sklodowska-Curie Action (MSCA) Innovative Training Networks (ITN) has received funding from the European Union's H2020 Framework Programme under Grant Agreement no. 764879

The people

<table>
<tr><th colspan="4">CERN</th><th>Uni Siegen</th><th>HZB</th><th>INFN-LNL</th></tr>
<tr><td>TE-CRG-CI</td><td>BE-RF-SRF</td><td>TE-VSC-SCC</td><td>TE-VSC-VSM</td><td></td><td></td><td></td></tr>
<tr><td colspan="3">Cryolab</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Torsten Koettig</td><td rowspan="2">Hernan F. Furci</td><td rowspan="2">Guillaume J. Rosaz</td><td rowspan="2">Sergio Calatroni</td><td colspan="2">Prof. Jens Knobloch</td><td></td></tr>
<tr><td>Johan Bremer</td><td rowspan="2">Stewart Leith (ESR14)</td><td rowspan="2"></td><td rowspan="2">Vanessa Garcia Diaz (ESR10)</td></tr>
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ESR1 main objectives

Experimentally qualify methods used by CERN for deposited layers and their quality

- Characterization of thermal properties of superconducting (SC) thin films deposited on substrate at low temperatures
- Development of a model and perform numerical simulation to predict the influence of thermal properties on the SC performance
- Compare results with ESR10 (INFN-LNL) and ESR14 (UniSiegen)

PhD objectives

On top of/parallel to ESR1 project:

- Characterizing the thermal parameters of the cooling path from the thin film towards the cold source (saturated He bath at/below 4.2 K), with special attention to the transition of He I to He II
- Interface thermal resistance
  V Palmieri and R Vaglio 2016 Supercond. Sci. Technol. 29 015004
- Extend the study to cavity structures with RF fields
- Participate in the SC cavity quench localization study

Plan and tasks – Year 1

- Literature research and gain of knowledge
- Definition of needs for the setup of the experimental test stations
  - Samples [CERN TE/VSC and BE/RF groups]
  - Measurement precision [CERN TE/VSC and BE/RF groups]
  - Data analysis [CERN TE/VSC and BE/RF groups, INFN-LNL, UniSiegen]
- Upgrade of existing test facilities and investigation of the possibility to establish a cryocooler setup to access variable temperatures in vacuum environment for RRR measurements

Test stands at Cryolab

Thermal expansion

4.2 K and 78 K

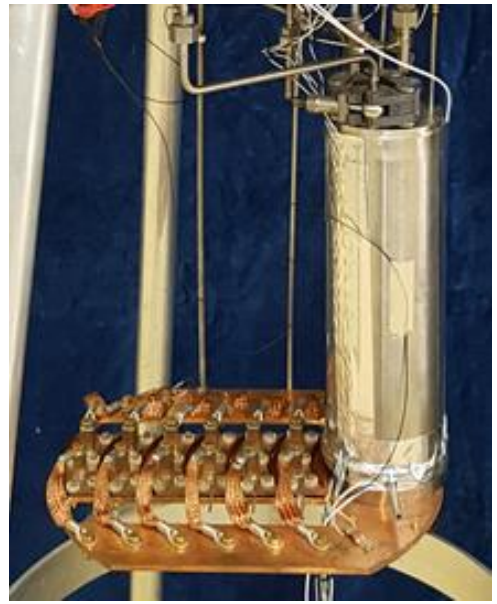
Set-up in LHe/LN_2
Bulk material samples

RRR and Tc of SC on substrates or bulk SC

4.2 K to 300 K

Set-up in He vapor
Nb on sapphire
Nb on quartz

Set-up in He vapor
SC on foil

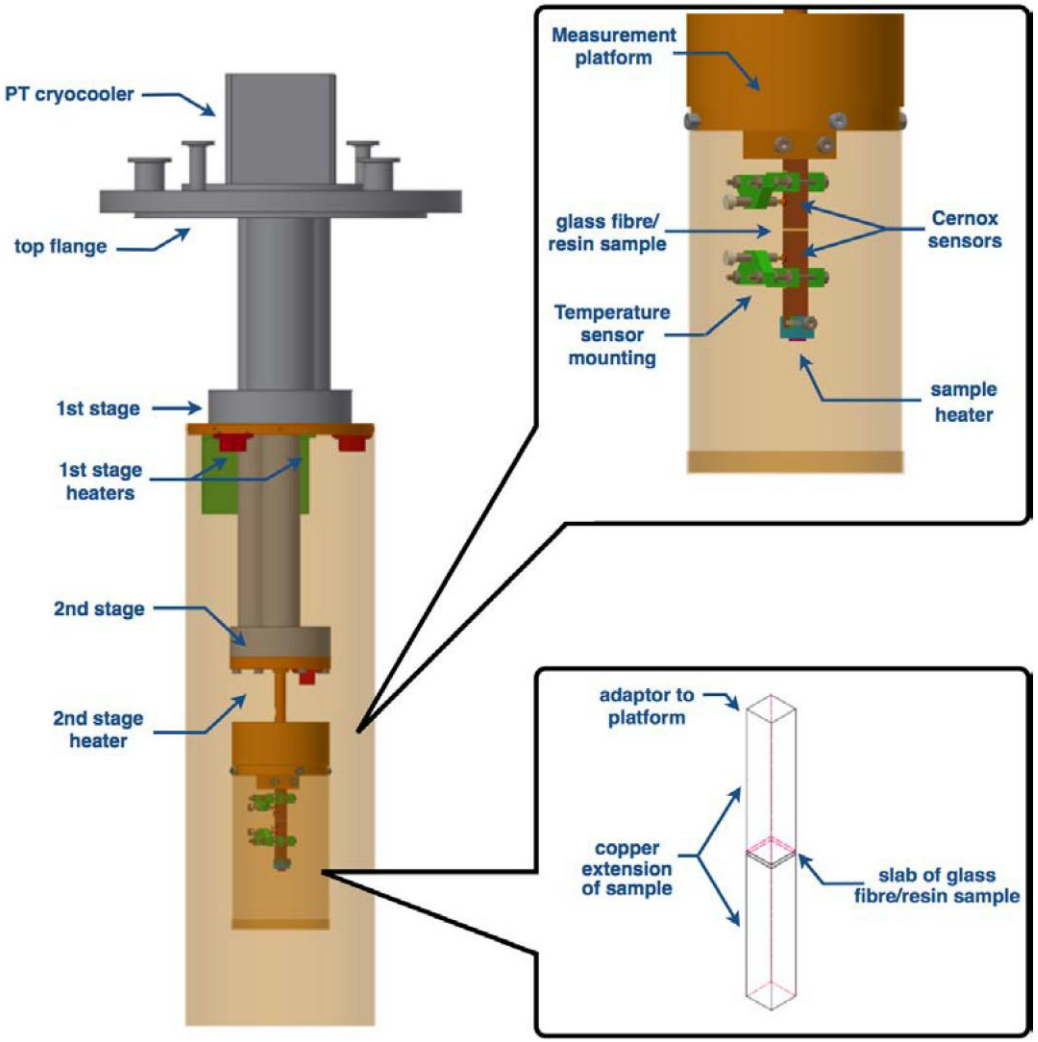


Set-up in vacuum
Bulk material samples
Curved and straight shape

Plan and tasks – Year 2

- Prepare a test stand to determine T_c of the thin films on metallic (Cu) substrate by magnetic induction in LHe environment (S. Calatroni, G. Rosaz from CERN TE/VSC)
- Study the interface thermal resistance of the SC film to its substrate (understand the feasibility of a Cryocooler-based thermal conductivity test stand)
- Develop a numerical simulation tool to study the transient thermal behavior of SC thin film structures (e.g. SC cavity geometries) [CERN BE/RF-SRF]

Thermal conductivity test stand



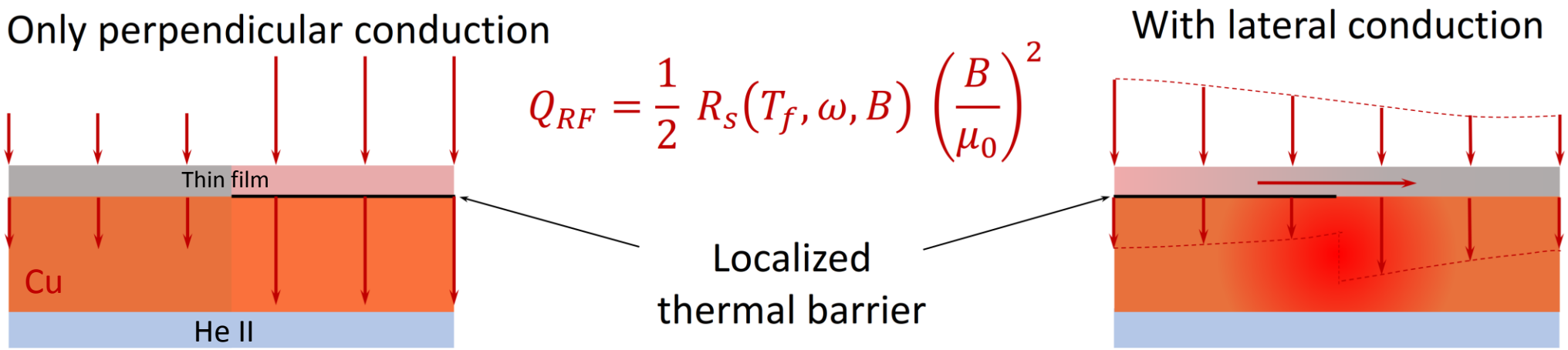
Existing test stand to measure thermal conductivity between 3 K and 290 K

- Pulse Tube Cryocooler (PTC) based cold platform ➜ sample in vacuum environment
- first stage of the PTC at 45 K: thermal shield and heat intercept
- second stage of the PTC: T= 2.6 K to 20 K
- experimental platform: T= 3 K to 30 K (100 K extended, during warm up to 290 K) and second shield thermalized at sample temperature

Plan and tasks – Year 3

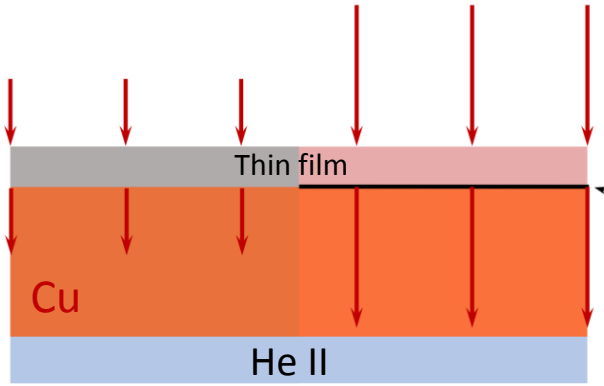
- Characterization of SC films as cavity structures with RF field
  Marco Arzeo's talk "Quadrupole resonators characterisation"
  FCC week 2018 – yesterday April 10th
- Comparison of the RF performance of SC thin films on substrate, in vacuum and He-bath cooling environment
- Participation in/contribution to the Quench Localization Study by using synergy effects between the Cryolab and the Cavity Diagnostics Project [CERN BE/RF-SRF]
- Writing of PhD thesis

Quench Localization Study



Quench Localization Study

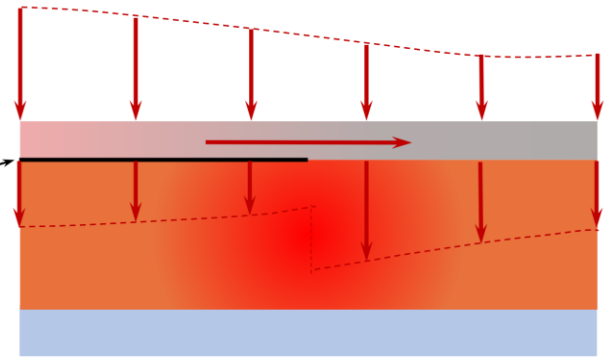
Only perpendicular conduction



$$Q_{RF} = \frac{1}{2} R_s(T_f, \omega, B) \left(\frac{B}{\mu_0}\right)^2$$

Localized thermal barrier

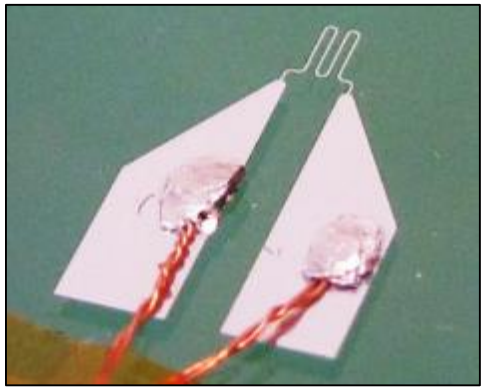
With lateral conduction



Oscillating Superleak Transducer

- sensitivity for 2nd sound in He II
- spatial resolution for quench localisation
- gaining further information from the temperature wave propagating in 3D

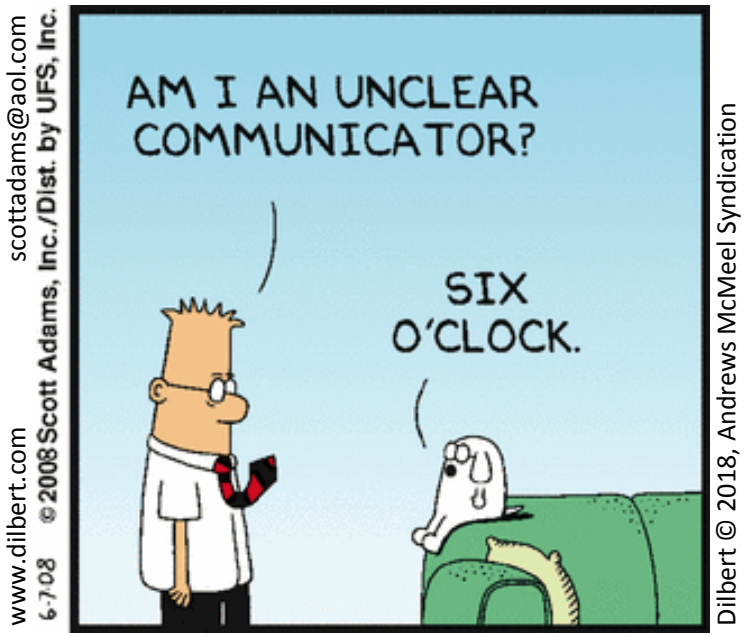
Transition Edge Sensor



Risks and challenges

- Nb_3Sn brittle
- Production of samples
- Characterization of SC film on Cu substrate is new
- Coordination with groups providing samples and know-how
- …

Thank you. Questions?



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