EASITrain

Summary report on Materials (WP2)

Michael Eisterer

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Contributions from Dorothea Fonnesu, Johannes Gnilsen, Alice Moros, Mattia Ortino

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European Commission

WP2 Materials

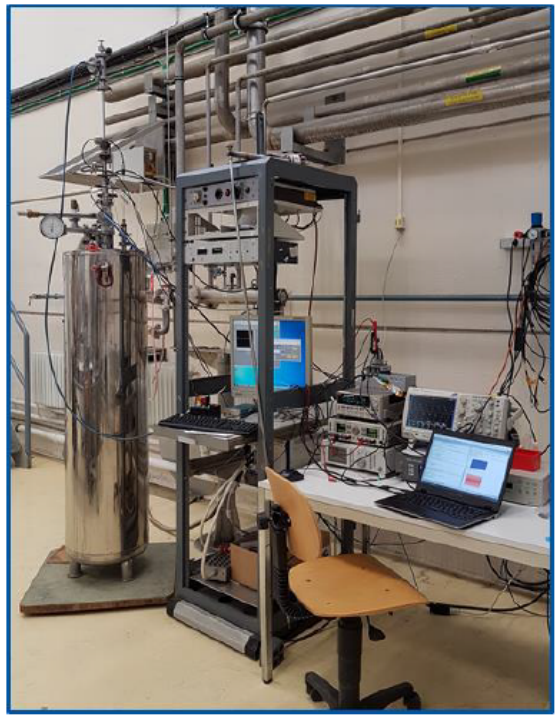
Beneficiaries/ESRs

- CERN: Dorothea Fonnesu
- BRUKER HTS: Johannes Gnilsen
- CNR-SPIN: Aisha Saba
- ASG: Mattia Donato / Paola Moceri
- Helmholtz Zentrum Berlin: Dmitry Tikhonov
- TU Wien: Alice Moros and Mattia Ortino
- Universität Siegen: Steward Leith

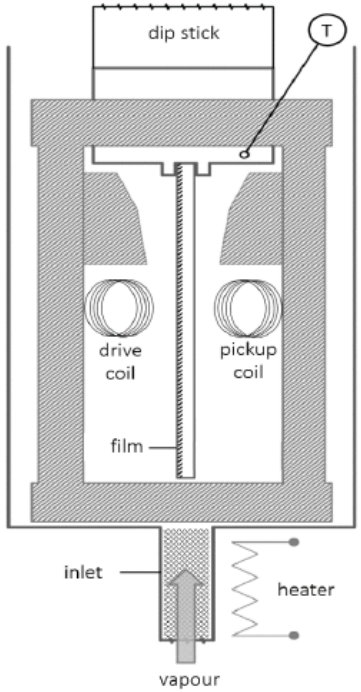
CERN: Dorothea Fonnesu

Critical Temperature Measurement @ CERN

Contactless, inductive measurement of the critical temperature of superconducting thin films deposited on copper.



- Characterise superconducting thin films deposited on copper
- Be active part of the R&D chain for coated copper SRF cavities
- Become independent of external support

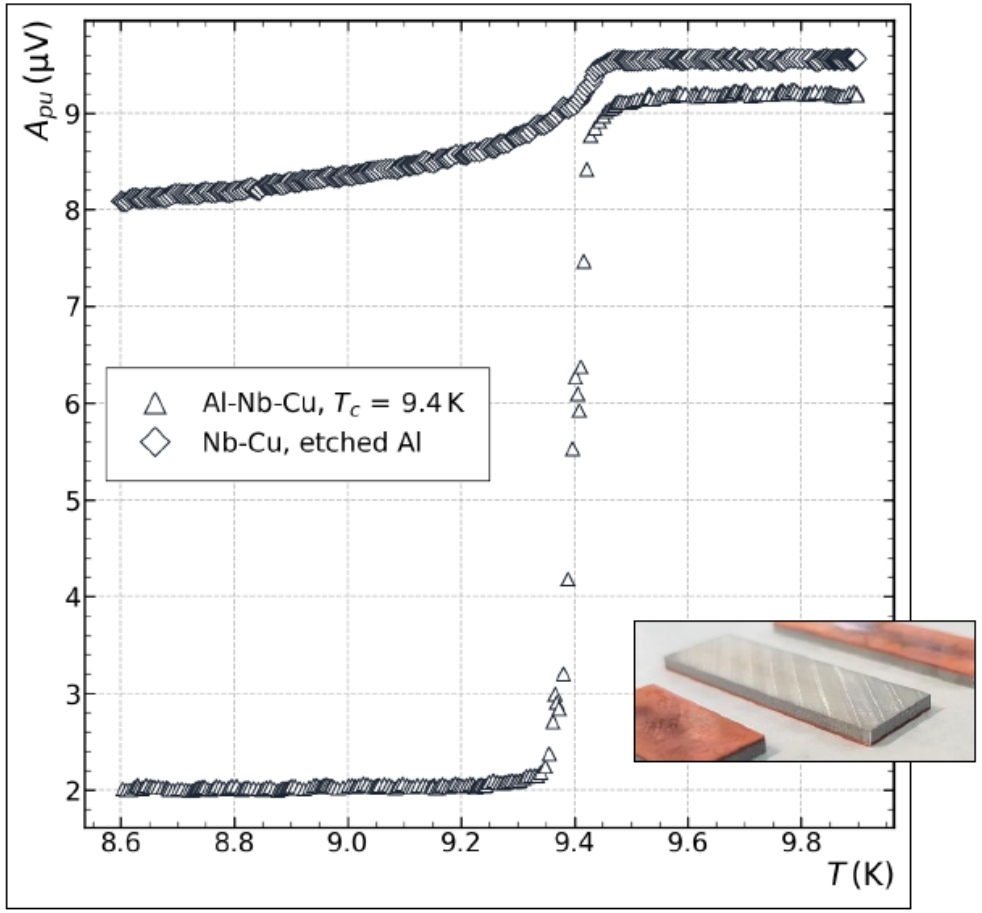


Scientific achievements

- Established a system for the contactless measurement of the critical temperature of superconducting thin films deposited on copper substrate
- Participated in:
  - study of film density for HiPIMS Nb/Cu coatings at grazing incidence angles (WOW cavities)
  - study of reverse coating technique to produce electro-formed copper cavities with integrated superconducting layer (graph)
  - study of quality of HiPIMS Nb_3Sn/Cu coatings

Career achievements

- Journal article in Thin Solid Films: "Improved film density for coatings at grazing angle of incidence in high power impulse magnetron sputtering with positive pulse" DOI: 10.1016/j.tsf.2020.138058
- ESR contract ended in January 2021
- currently working on PhD by University of Siegen under DOCT contract at CERN

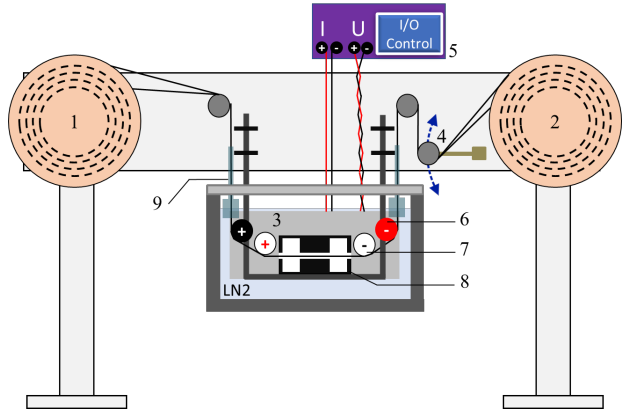


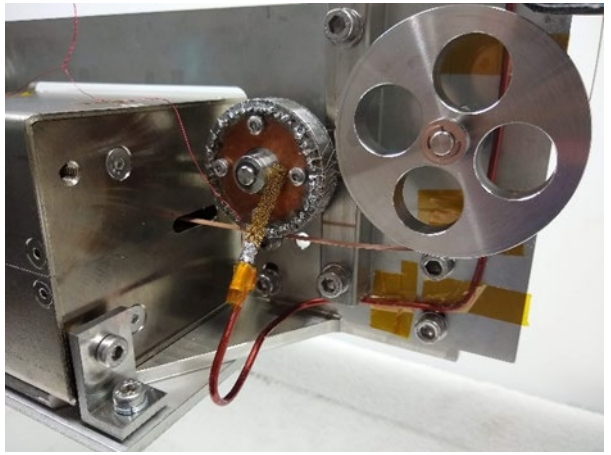
SC transition of the niobium film before the etching of the aluminium disk/mandrel (bottom graph) and after (top graph). The etching of the aluminium results in the degradation of the superconducting performance of the niobium film. The picture in the small insert shows a Al-Nb-Cu sandwich sample.

BRUKER: Johannes Gnilsen

- **Project Goal**
- Development of I_c scanner (M-Scan) for coated conductors at 77 K and 2.61 T

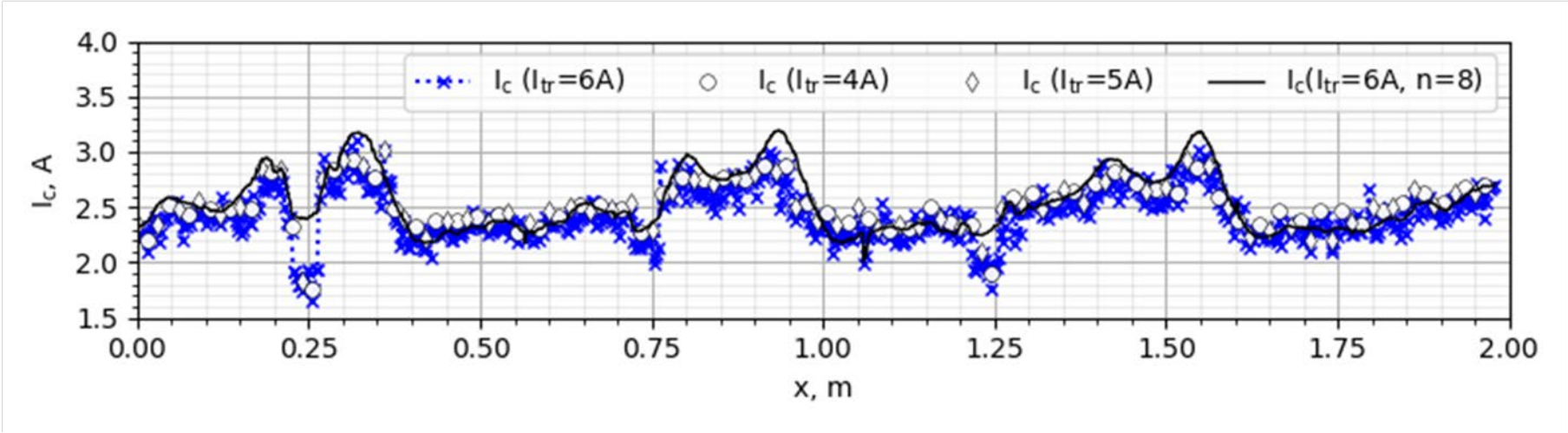
- **Main Achievements**
- Development of extended alpha approximation (EAA approach) for tape characterization
- Successful development and implementation of M-Scan device
- Successful tape scans with a length of up to 100 m.
- Successful determination of critical current $I_c(x)$.
- Comparison of I_c with other I_c-scan devices (Hall array scanner)
- Investigation of impact of tape defects on critical current with the developed ‚EAA approach‘.





BRUKER: Johannes Gnilsen

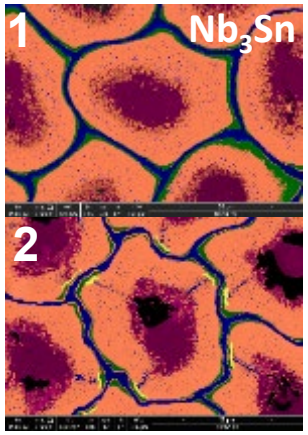
- Determination of Ic(77 K, 2.61 T) for a 2 m long test tape with high Ic-inhomogeneity and artificially introduced defects.
- Critical current is determined from voltage drop due to applied constant transport current Itr.
- Repeated scans show that determined critical current is independet of pre-selected transport current (Itr = 4-6A).

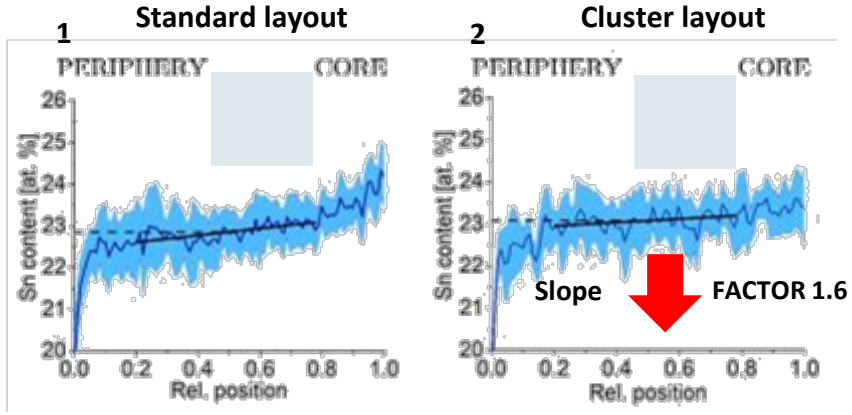


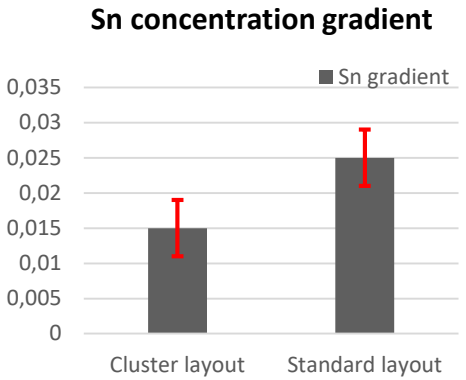
TU Wien: Alice Moros

- Homogeneity investigation in terms of Sn concentration gradient of internal tin Nb_3Sn wires with standard and cluster configurations

Same heat treatment, same size and sub-elements number





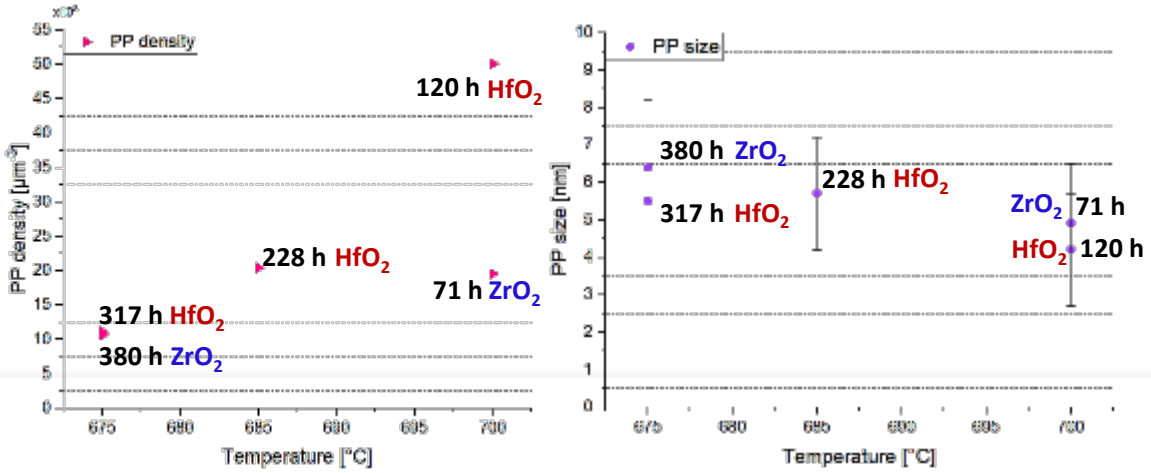


Potential of cluster layouts for producing more homogeneous wires with optimized superconducting performance

A. Moros et al., "Nb3Sn Wires for the Future Circular Collider at CERN: Microstructural Investigation of Different Wire Layouts," IEEE Transactions on Applied Superconductivity 31, no. 5 (2021): 6000405.

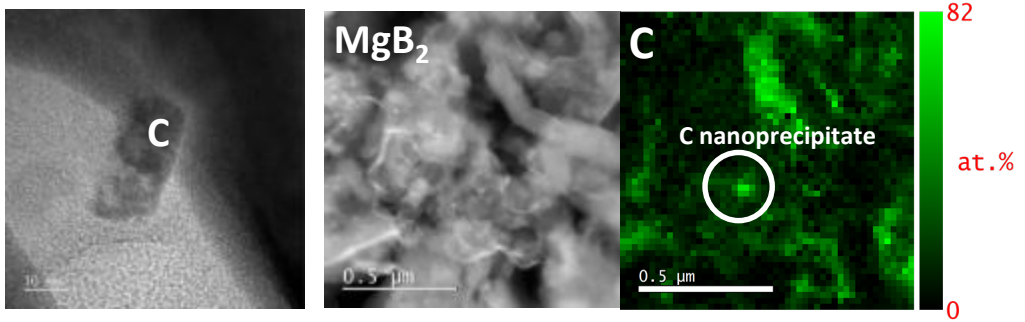
- Exploration of nanoprecipitates behaviour in APC (artificial pinning centres) Nb_3Sn wires and C-doped MgB_2 wires

APC Nb_3Sn : HfO_2 and ZrO_2 nanoprecipitates (PP) density and size



No direct relationship yet between PP size + density and heat treatment parameters

C-doped MgB_2 : analysis of C distribution within the MgB_2 matrix



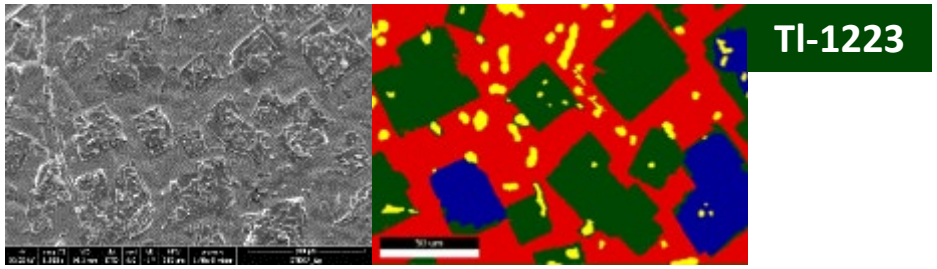
Capra, M., F. Loria, C. Bernini, G. Bovone, A. Moros et al. "Method for the production of pure and C-doped nanoboron powders tailored for superconductive applications," Nanotechnology 31, no. 49 (2020): 494001.

C nanoaggregates size between 10 nm and 50 nm, spaced 10 to 100 nm apart with great potential as pinning centres

TU Wien: Alice Moros

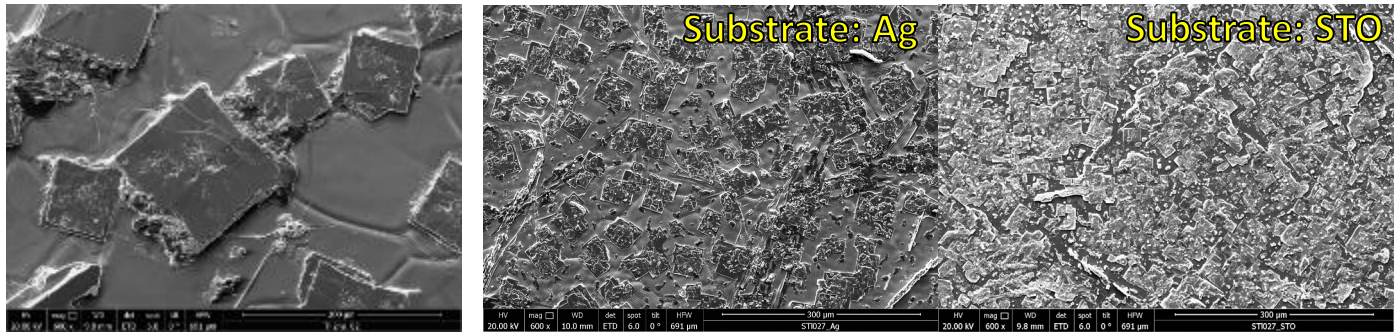
- Investigation of Tl-based thin films: evaluation of Tl-1223 phase formation and substrate coverage

Tl-1223 phase formation evaluation: more Tl-1223 than Tl-1212



Leveratto, A., A. Saba, S. Holleis, M. Himmerlich, B. Henrist, S. Fernandez-Peña, A. Moros et al. "Future Circular Collider beam screen: progress on Tl-1223 HTS coating," Superconductor Science and Technology 33, no. 5 (2020): 054004.

Substrate coverage: new films (b) showed a better coverage than the old ones (a) - SEM images taken at the same magnification



a **b**

Confirmed improvements of the manufacturing process towards the production of optimized Tl-1223 thin films

- PhD defense done (7th September 2021)
- 2 years post-doc at Lawrence Berkeley National Laboratory (LBNL) , Berkeley – California

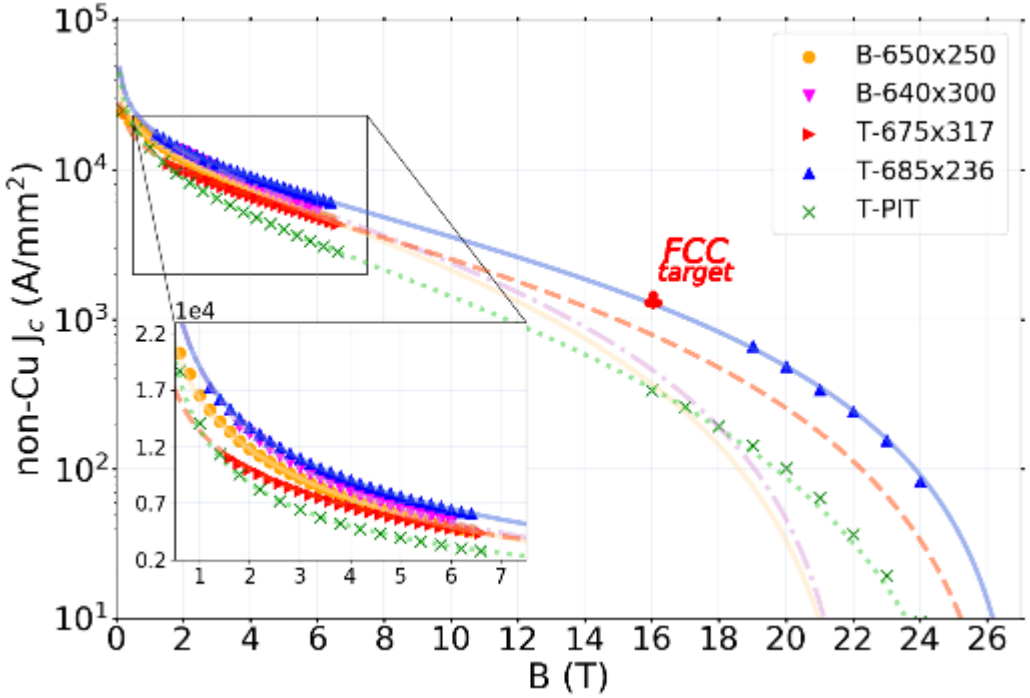
Start date: 11th October 2021

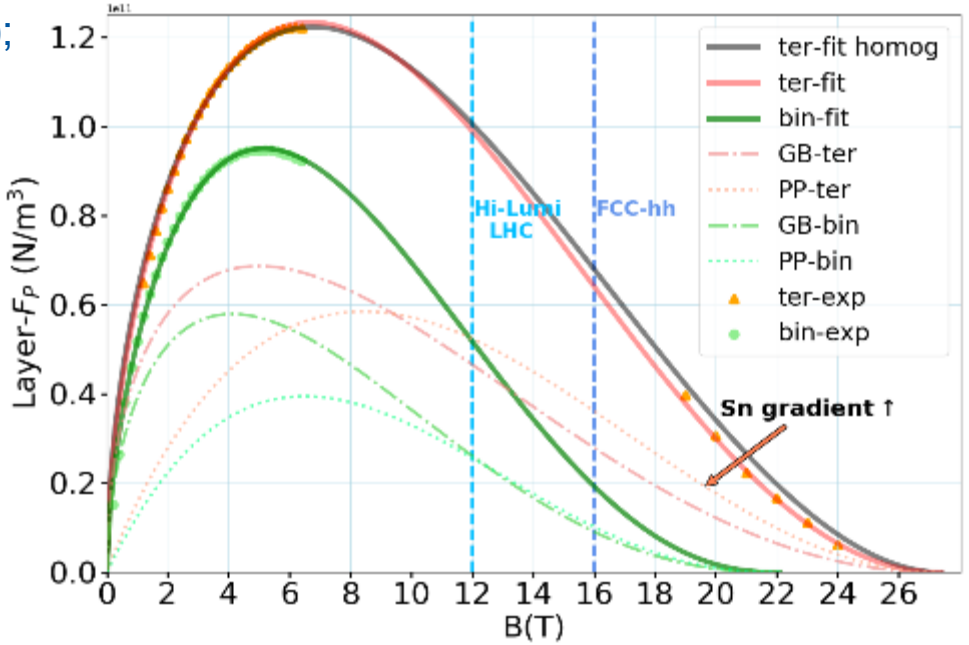
TECHNISCHE UNIVERSITÄT WIEN
Vienna University of Technology

Mattia ORTINO

Scientific

- Systematic study of APC-Nb_3Sn technology: record performance Nb_3Sn wires for hh-FCC 16 T dipoles (from prototype monofilamentary to optimized 217-filaments samples); (*Ortino et al., 2021 SUST*)
- Magnetometry based method for establishing sub-elements sizes in multi-filamentary structured superconductors; (*Ortino and Eisterer, 2021 IEEE Transactions)*
- Characterization of other viable Nb_3Sn and MgB_2 samples for hh-FCC (collaboration with ESR12, Alice Moros);
- Flux pinning modelling for a better description of the APC-Nb_3Sn physics (to be published soon);





- Successful secondments in ASG (collaboration with ESR7) and Ohio State University (2-papers)

Career development

- Contract ended;
- PhD Thesis ~ handed in, almost over;
- Looking for new job;

WP2 Materials

Personal summary (WP2 leader)

- Interesting and successful research projects.
- Successful training of ESRs.
- Completion of PhD hardly feasible „on-time“. Some already finished others will follow.
- Collaboration between beneficiaries was satisfactorily.