EASITrain Final Event
WP3 Summary Report

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WP3 Manufacturing Beneficiaries

Aisha Saba (ESR6)

Paola Mauceri (ESR7)

Jean Francois Croteau (ESR9)

Vanessa Garcia (ESR10)

Stewart Leith (ESR14)

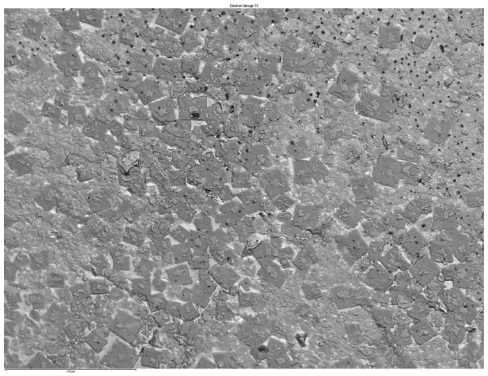
ESR6 – Aisha Saba

Production of HTS Thallium-based thin-film coatings

Thallium-based coatings are one of the innovative superconductors explored for the **Future Circular Collider Beam Screen**

Improvement in desirable phase and coverage of thallium thin films deposited on silver substrates were obtained by:

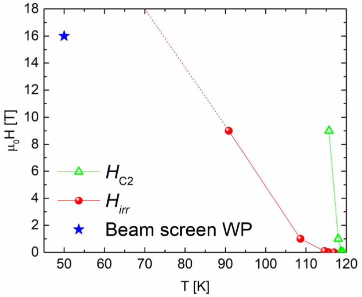
- Optimizing the annealing temperature time and temperature
- Pulse potential deposition
- Treatment with unreacted pellet
- Modified gold capsule for treatment of Tl-films



A SEM image of annealed thin film

ESR6 – Aisha Saba

Production of HTS Thallium-based thin-film coatings



Summary of the results:

- ❑ Not only morphology of Thallium based thin films and bulk samples was improved but also superconducting properties were enhanced:
  - ***very high Irreversibility Magnetic Field***
  - ***Critical current density Jc ~ $8x10^{10}$ Am^{-2}***
- ❑ Optimised Electrodeposition technique and annealing processes helped to improve superconducting phase, coverage and superconducting properties for the deposition of thallium thin films.
- ❑ Reasonable degassing rate, secondary electron yield (low as 0.77), no detection of heavy elements in residual gas analysis make **thallium based superconductors vacuum applicable material.**

Publications:

- *Future Circular Collider beam screen: progress on Tl-1223 HTS coating* - A Leveratto et al., 2020 Supercond. Sci. Technol. 33 054004

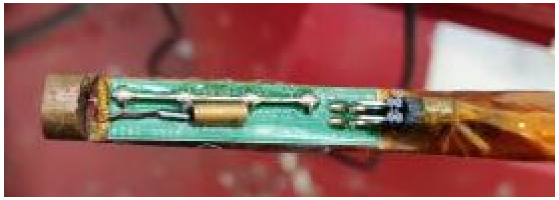
A new project ADDENDUM FCC-GOV-CC-0217 (KE5072/TE) has been started to realise the more potential of thallium based thin film for the beam screen coatings

ESR7 – Paola Mauceri

Development of MgB_2 wire for high-field magnet applications

Set up of RRR and Tc measurement system


Old measurement system

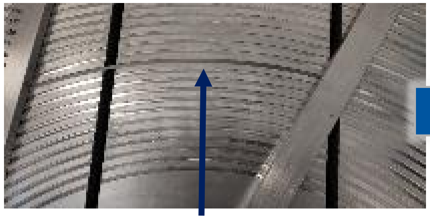

New measurement system

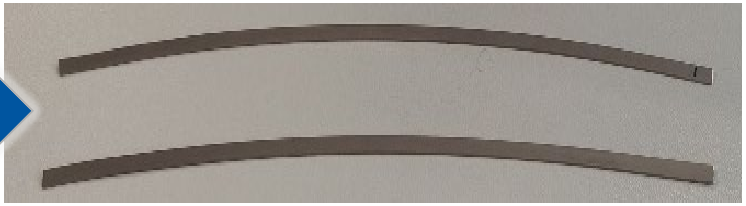
New system characteristics

- ❑ Use of a Printed Circuit Board (PCB)
- ❑ Fixed sample length
- ❑ Fixed distance between the voltage sockets
- ❑ Fixed sample position
- ❑ Fixed termometer position
- ❑ Solder with solder paste

Bending radius Test of MgB_2 wires and tapes

Development of new templates with different radius values for easy and hard bending test of MgB_2 wires and tapes.
Limit values of bending radius at room temperature, for the production and handling, were obtained.


Tapes hard bending


Bent MgB2 Tapes in hard way

ESR7 – Paola Mauceri

Development of MgB_2 wire for high-field magnet applications

Set up of the Tensile Test machine and improvement of the mechanical Test of MgB_2 wires and tapes

- Tensile Test procedure for MgB_2 wires and tapes were defined
- Mechanical properties of MgB_2 wires and tapes at room T were obtained using the new precise procedure
- Electromechanical properties of MgB_2 wires and tapes at room temperature were studied
- Limit of strain values at room T were obtained. Critical current (Ic), degradation as a function of the applied strain was estimated. Important values for the production and handling.

Development of the intergrain connectivity study of MgB_2 powders

- Samples with MgB_2 powder were prepared, emptied using an acid solution and measured by the R(T) test to calculate the resistivity values of the MgB_2 powder.
- The intergrain connectivity (F) was calculated using the shown equation. The resistivity values of a single crystal of MgB2, were used.

$$\rho(T) = F[\Delta\rho_{sc}(T) + \rho(0)] \qquad \Delta\rho = F[\Delta\rho_{sc}]$$

- Research still to be completed and improved

Permanent position at ASG Superconductors will start in October 1st

ESR9 – Jean Francois Croteau

I•CUBE

Material characterization to improve different forming techniques and increase the performances of SRF cavities

Materials

Niobium

Single crystals

Niobium Single Crystals

- Effect of strain rate on the mechanical properties and on the microstructure of niobium single crystals with different crystal orientations
- Reduction of anisotropy at high strain rate in tension
- Reduction of ductility with increasing strain rate
- Shorter and more homogeneously distributed dislocations at high strain rate

OFE Copper + Niobium

Polycrystals

Forming Limit Diagrams

- The FLDs of annealed OFE copper and polycrystalline niobium were measured with Marciniak (in-plane) tests
- Niobium is more ductile than annealed OFE copper

Electron Beam Welded Sheets

- The EB welds have little effects on the yield and tensile strengths
- Ductility reduction for niobium at high strain rates (similar to single crystals)

Publications

Nb single crystals: Materials Science and Engineering: A, Sep. 2020, DOI: 10.1016/j.msea.2020.140258
EBW of Nb and Cu: Journal of Dynamic Behavior of Materials, Jan. 2021, DOI: 10-1007/s40870-021-00293-9
FLD of niobium: Journal of Engineering Materials and Technology, approved Aug. 2021, awaiting DOI

ESR9 – Jean Francois Croteau

I·CUBE

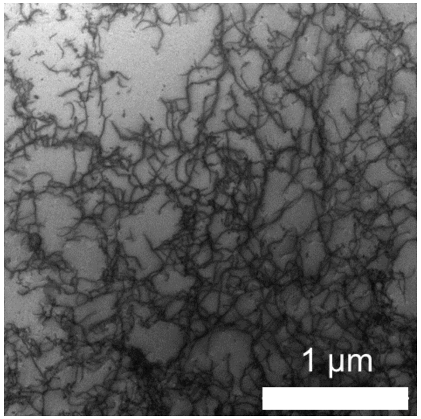
Material characterization to improve different forming techniques and increase the performances of SRF cavities

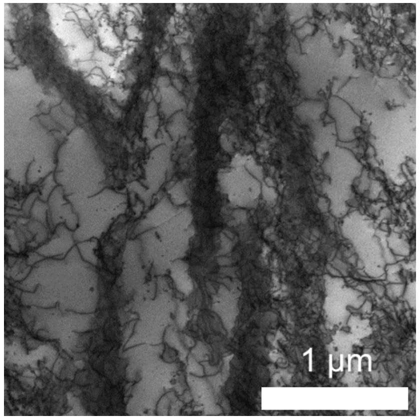
Niobium Single Crystals

- Effect of strain rate on the mechanical properties and on the microstructure of niobium single crystals with different crystal orientations

Low strain rate ($1.28 \times 10^{-3}\ s^{-1}$)

- Long dislocations
- High dislocation density
- Dislocations often in preferred orientations
- Cell walls close to the fracture surface

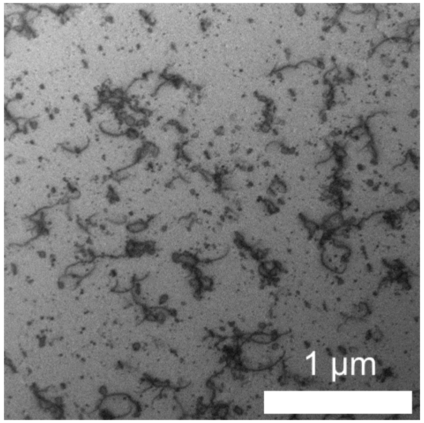


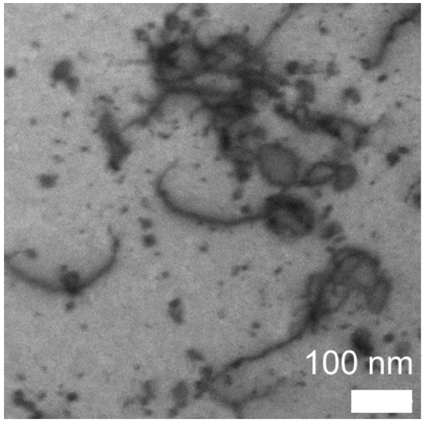


fracture surface

High strain rate ($\sim 1000\ s^{-1}$)

- Short dislocations
- High dislocation dipole density (short loops)
- Homogeneously distributed dislocations



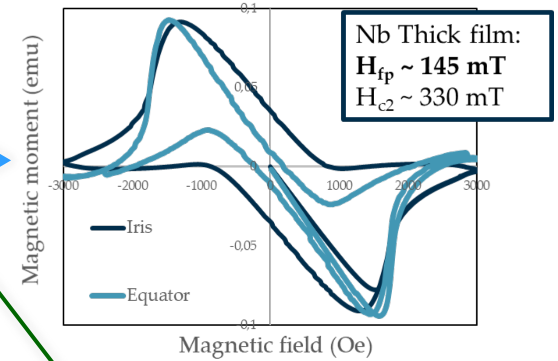


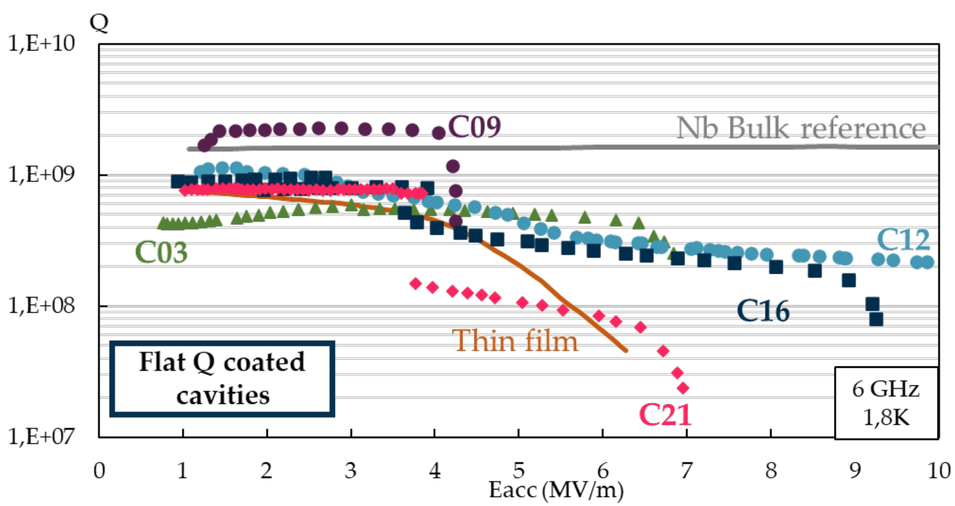
ESR10 – Vanessa Garcia

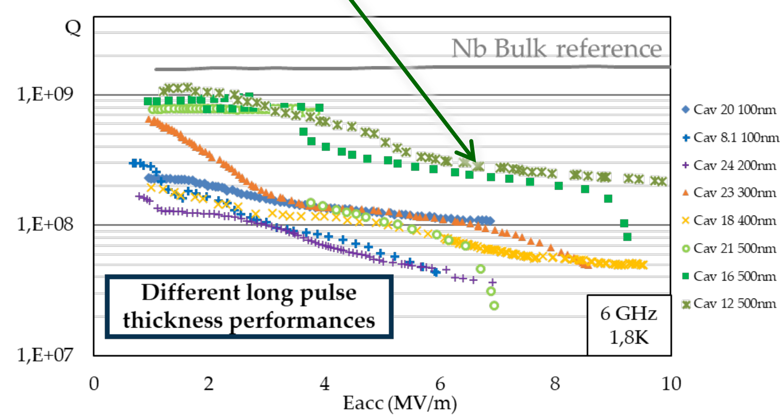
Advanced surface coating techniques for SRF cavities

Thick film coated 6 GHz cavities RF performances

- Nb thick films between 45 and 70 μm
- Q-slope mitigation at low accelerating fields
- Long pulse DC magnetron sputtering technique
- Low defects Nb film (very good flux expulsion)
- Higher accelerating field systematically for 500 nm single pulse layers







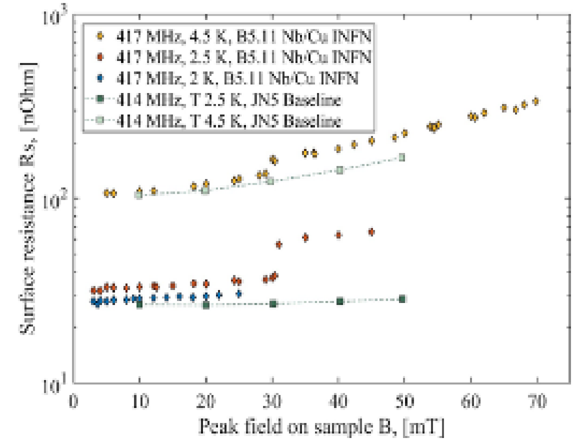
ESR10 – Vanessa Garcia

Advanced surface coating techniques for SRF cavities

Collaborations

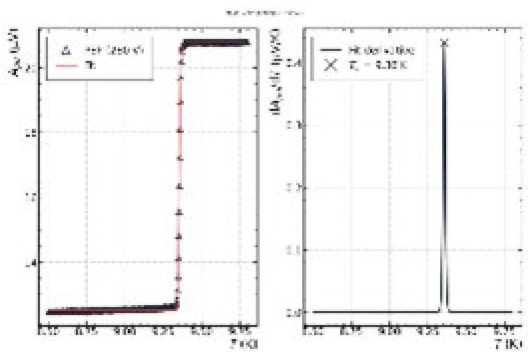
ESR8

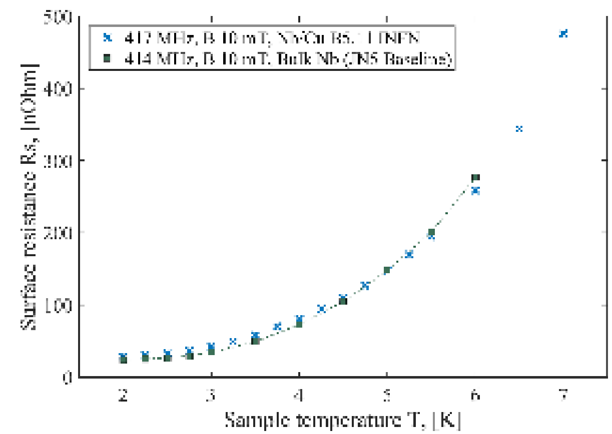
- QPR sample coated with Nb thick film
- Similar Q-switch as in 6 GHz cavities
- Very high peak field of 70 mT (highest measured for Nb)



ESR1

- RRR and Tc characterizations show a sharp transitions





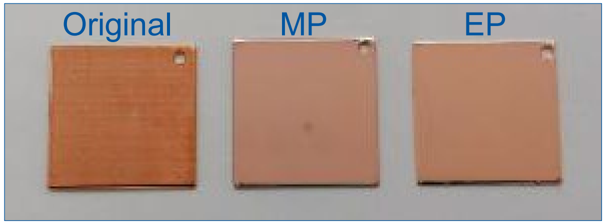
Publications

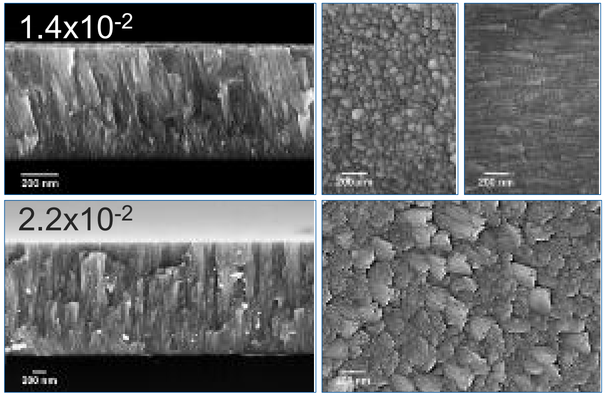
- Two SRF conference proceedings (2019/2021)
- Paper in preparation

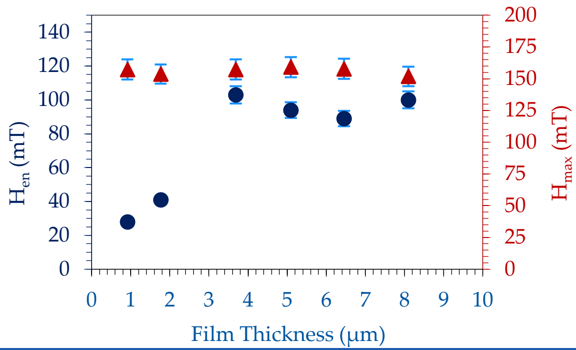
ESR14 – Stewart Leith

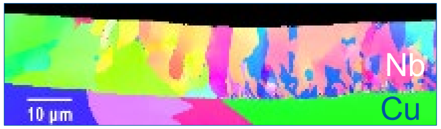
Production of superconducting NbN thin films

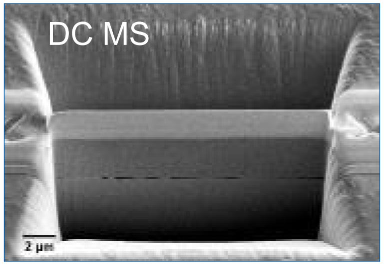
- Developed in-house copper surface treatment process
- High T_c NbN films realised with DC Magnetron Sputtering (DC MS)
- Improved superconducting performance of NbN films with High Power Impulse Magnetron Sputtering (HiPIMS)
  - Decreased surface roughness
  - Layer densification
- Improved Nb/Cu interface conditions compared to DC MS coatings through the use of HiPIMS – Less voids
- Definitive thickness dependence of entry field of Nb thin films
- Grain structure effects on growth of Nb thin films

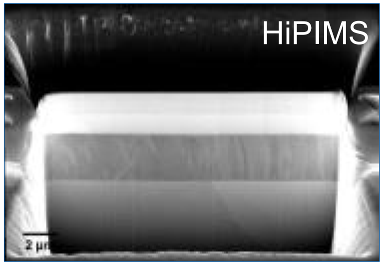










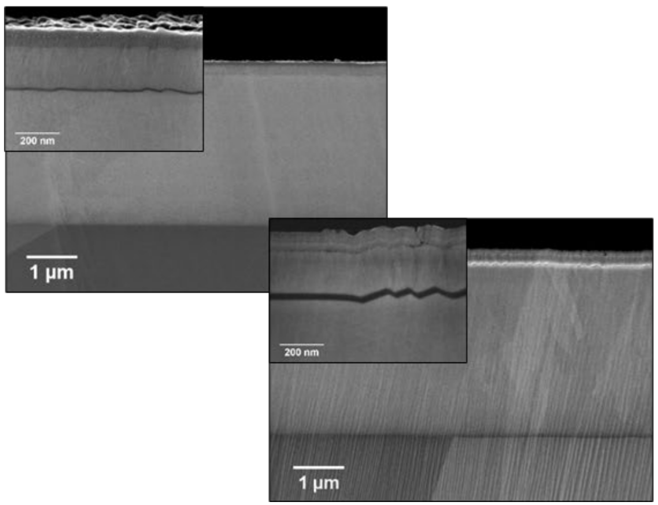


ESR14 – Stewart Leith

UNIVERSITÄT SIEGEN

Production of superconducting NbN thin films

- Developed multilayer SIS film coatings on Cu substrates, using both DC MS and HiPIMS
- Realised QPR samples coated with Nb and/or SIS films for ESR 8

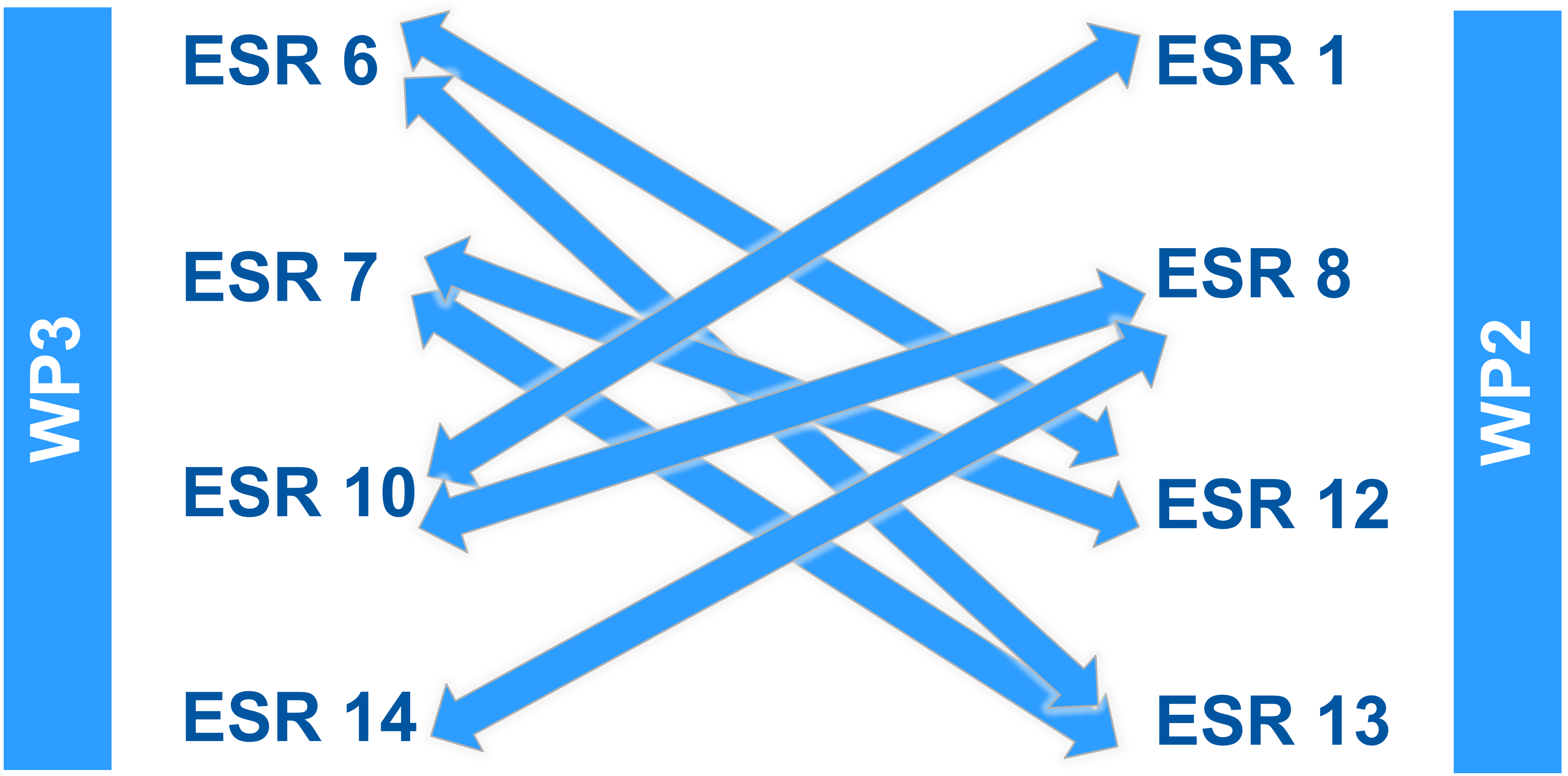


Publications

- NbN thin films, Superconductor Science and Technology, 2021,DOI: 10.1088/1361-6668/abc73b
- HiPIMS Nb thin films, to be submitted, 2021

- Four SRF conference proceedings (2019/2021)

Collaborations between ESRs



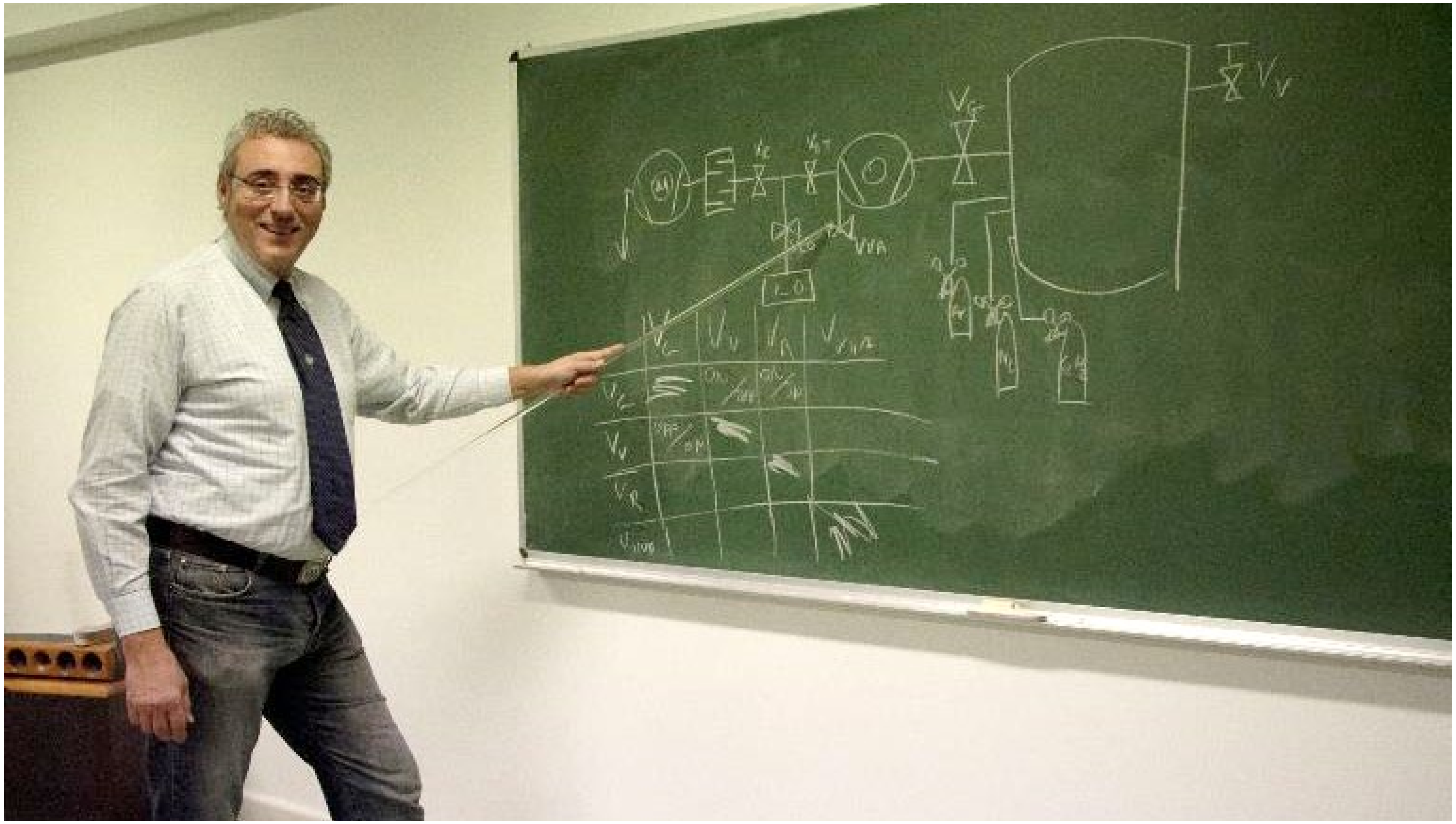
WP3 Deviation from original plane

- ESR7 Mattia Donato left EASITrain in August 2019
- New ESR7 Paola Mauceri join EASITrain in January 2020

- ESR7 Supervisor Matteo Tropeano left EASITrain in May 2020 replaced by Daniele Magrassi

- ESR9 Supervisor Elisa Cantergiani left EASITrain in September 2019 replaced by Gilles Mazars

Enzo Palmieri



Conclusions

- Very good scientific results
- All milestones achieved
- Established connection between ESRs and labs
- High level researchers formed

Thank you

- To all **ESRs** and **Supervisors** for making my coordination work easier

- To **Sergio Calatroni (WP3 deputy), Johannes Gutleber, Michael Benedikt, Ani Yaneva, Coralie Hunsicker, Emilie Nicole David, and all the EASITrain team** for the continuos help and support