

IEA HTS TCP Spring ExCo Web-Meeting



Italy Country Update Applied HTS Superconductivity Research

L. Serri, G. Angeli

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The role of Italy in the research on HTS applied superconductivity:

- **Italian National Project: Ricerca di Sistema (RdS)**
- **Initiatives based on the European funds against Covid pandemic (National Plan for Recovery and Resiliency – PNRR)**
 - a) PNRR about Hydrogen (**PNRR H2**)
 - b) PNRR about Infrastrutture (**IRIS**)
- **European Projects**
 - c) FASTGRID (**completed!**)
 - d) Scarlet (**starting in September!**)

Italian National Project: Ricerca di Sistema (RdS)

Studies and experimentations of HTS tapes and windings for SFCL devices



- **Development of methods for the measurement in cryogenic conditions of the resistance of HTS tapes and metallic materials.**

The innovative methods developed by RSE are based on the use of cryocoolers that allow the achievement of extremely low temperatures up to about 15 K inside a vacuum chamber.

- **Direct current (DC) tests for the evaluation of the critical current.**

The injection of the current into the sample was carried out by means of an increasing ramp followed by a decreasing ramp at five different temperatures between 77 K and 65 K.

- **Analysis and elaboration of alternating current (AC) tests for the evaluation of losses on HTS tapes at various temperatures.**

The AC experimental methods applied to HTS windings are based on the injection of sinusoidal alternating currents at 50 Hz and with variable amplitude for the duration of 10 periods (200 ms). The tests were carried out at different temperature values of the liquid nitrogen bath between 65 K and 77 K for a total of over 600 different tests.

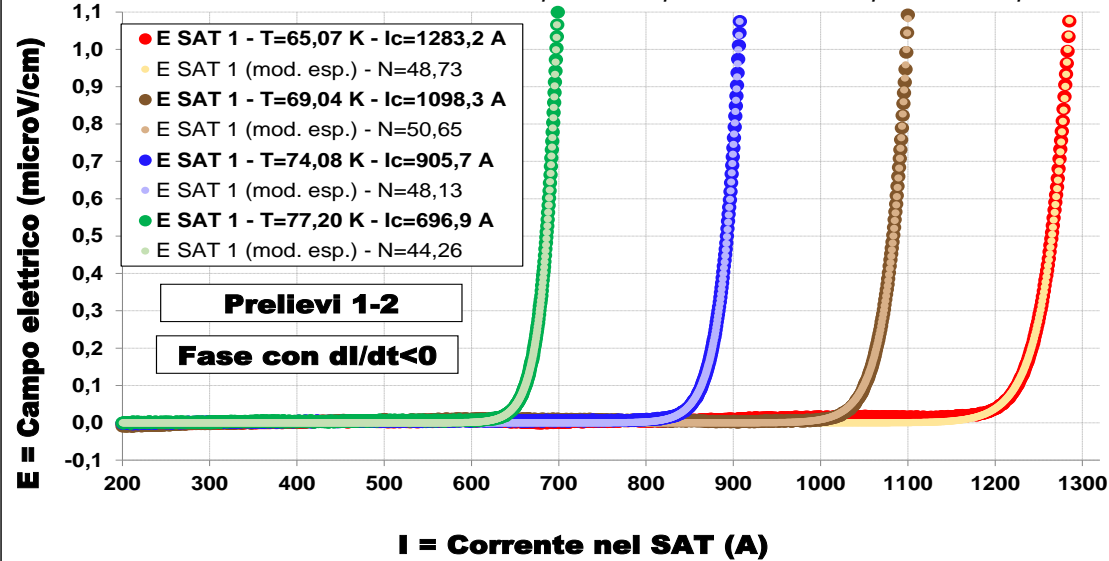
- **Numerical simulations for analyzing the use of SUNAM laminated 2G tapes in SFCL for electric power grids.**

The results of the processing of the measurements on the new Sunam GdBCO-based tapes were also used to obtain the formulations and parameters of the representative functions of the electrical and thermal properties of these tapes to be used as input in the simulation model of the behavior in short-circuit of the SFCL developed by RSE.

Campo elettrico non induttivo nel SAT in funzione della corrente

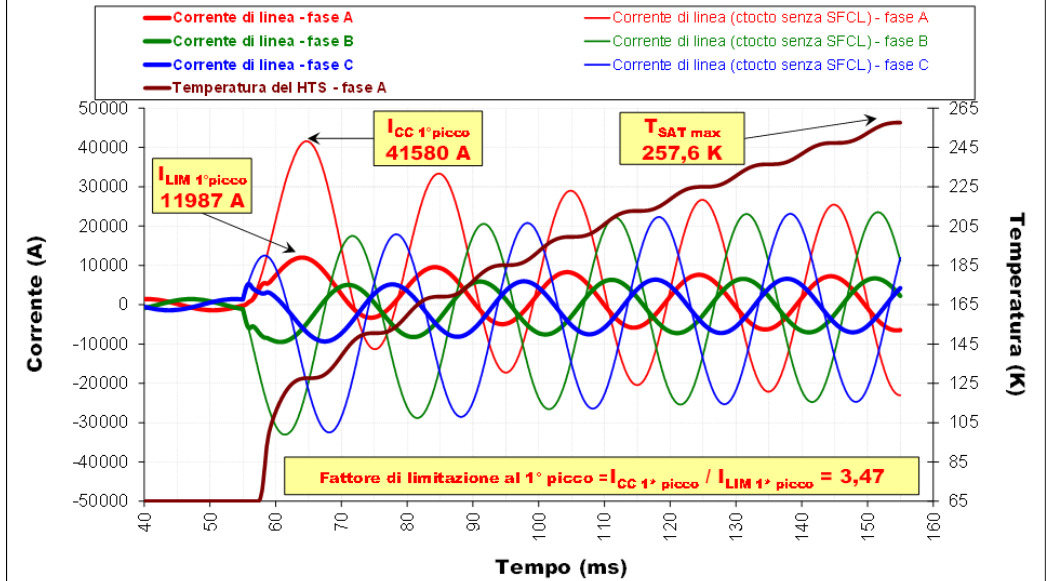
Campione SAT lineare laminato **SUN03-21** 2G base di GdBCO, **E SAT 1** tra **prelievi 1 e 2**

Confronto tra misure elaborate e modelli esponenziali per test in azoto liquido a 4 temperature



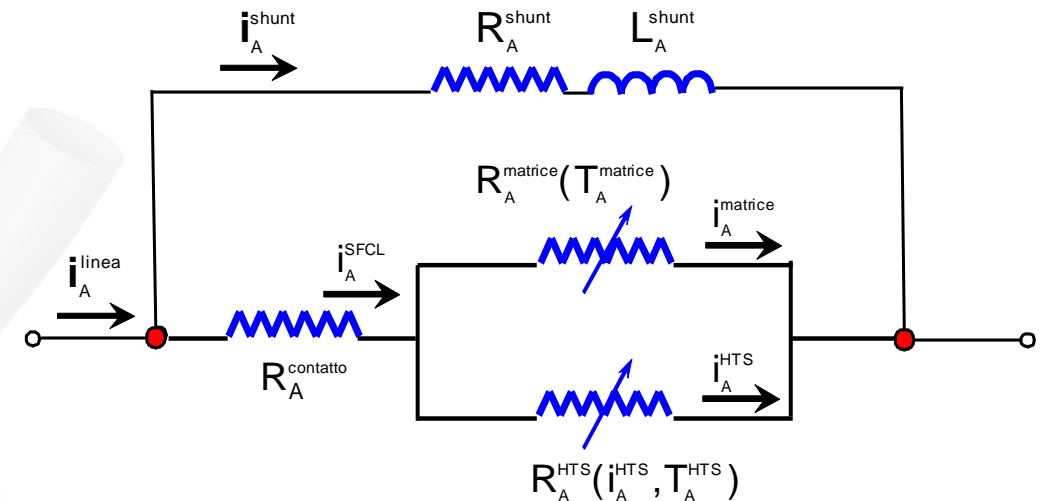
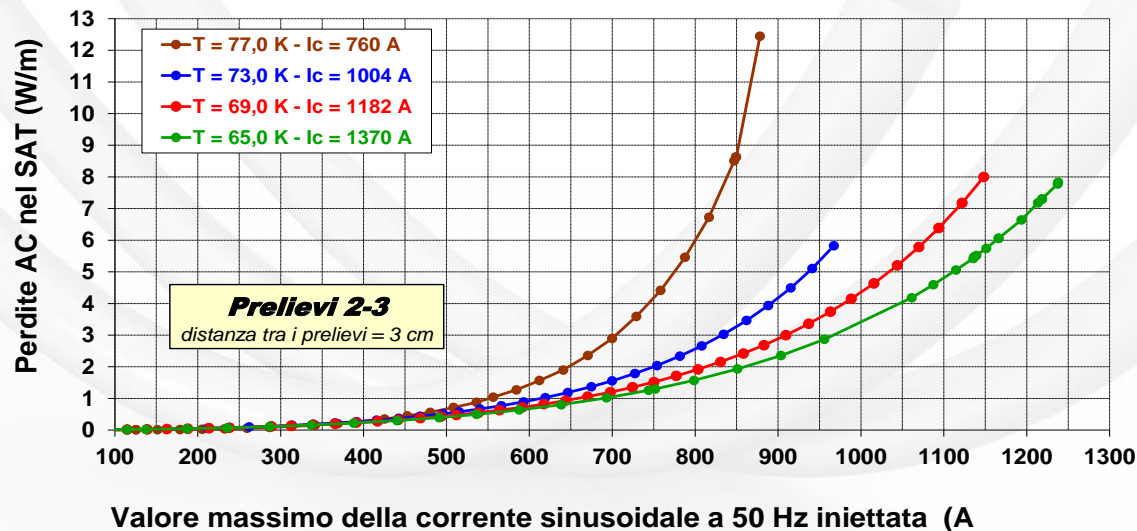
CORRENTI DI LINEA CON E SENZA SFCL DURANTE IL CORTO CIRCUITO

$N_{vib} = 2$ - $T_{iniziale} = 65,0$ K - $Z_{shunt} = 2,0 \Omega$ - L_{SAT} per via e fase = 250 m - Nastro SAT 2G laminato in acciaio di SuNam



Perdite AC nel SAT al variare della corrente a 50 Hz a diverse temperature

Campione lineare **SUN07 2021 non laminato** 2G a base di GdBCO di SuNam



M.Bocchi: Approfondimenti relativi alle attività teoriche e sperimentali su nastri e avvolgimenti SAT per dispositivi SFCL – 2021 (N.Protocollo: 21012576) [RdS Deliverable in Italian]

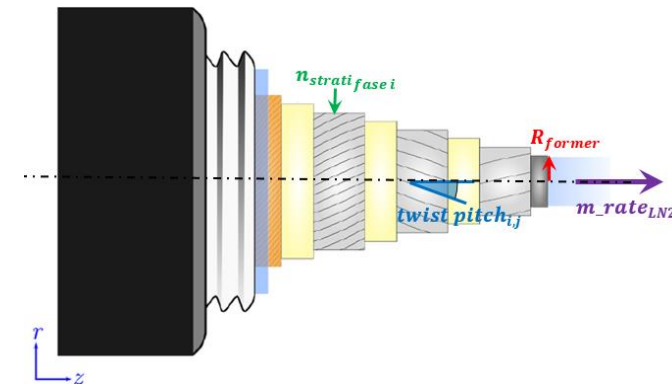
Italian National Project: Ricerca di Sistema (RdS)

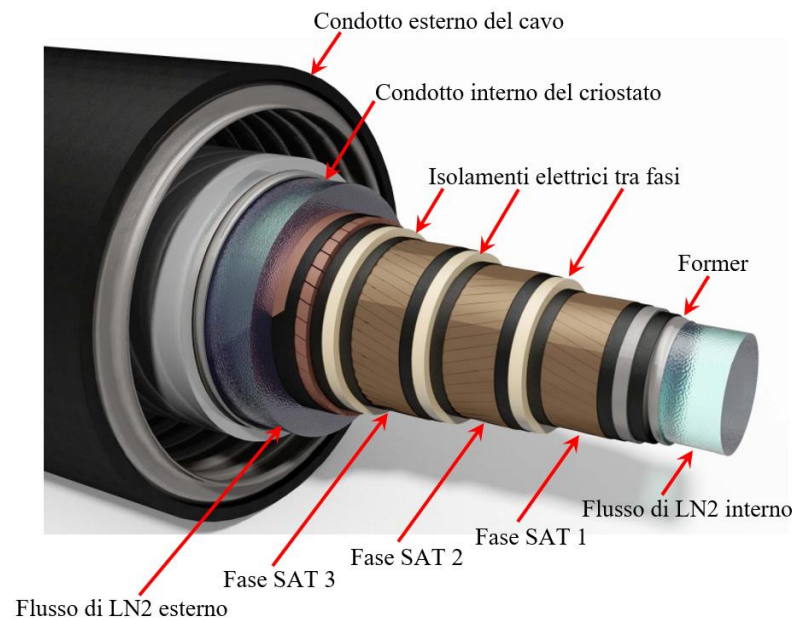
Studies and model activities for the analysis of HTS AC and DC cables behaviour and their installations possibilities in power grids.



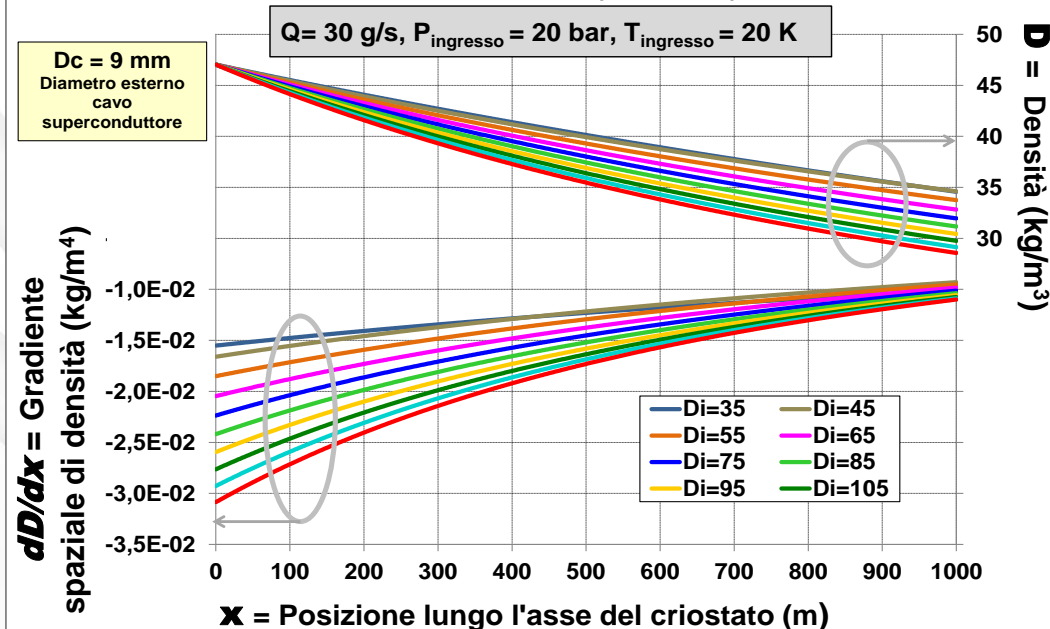
- The activities about the fluid-dynamic models validation and the development of electric models for techno-economic evaluations were carried-out.
- Methodologies have been developed for verifying the accuracy and numerical precision of the RSE model
- We also proceeded to the identification and implementation of new formulations for the thermal power entering the cryostat and for the friction factor between fluid and cryostat.
- A methodology has been developed for the optimization of the configuration of coaxial HTS cables under different operating conditions. This activity is part of the general analysis of the electrical behavior of superconducting cables for the national electricity network, aimed at defining any technical-economic advantages compared to conventional resistive cables.

Collaborations: University of Bologna,
Politecnico di Torino

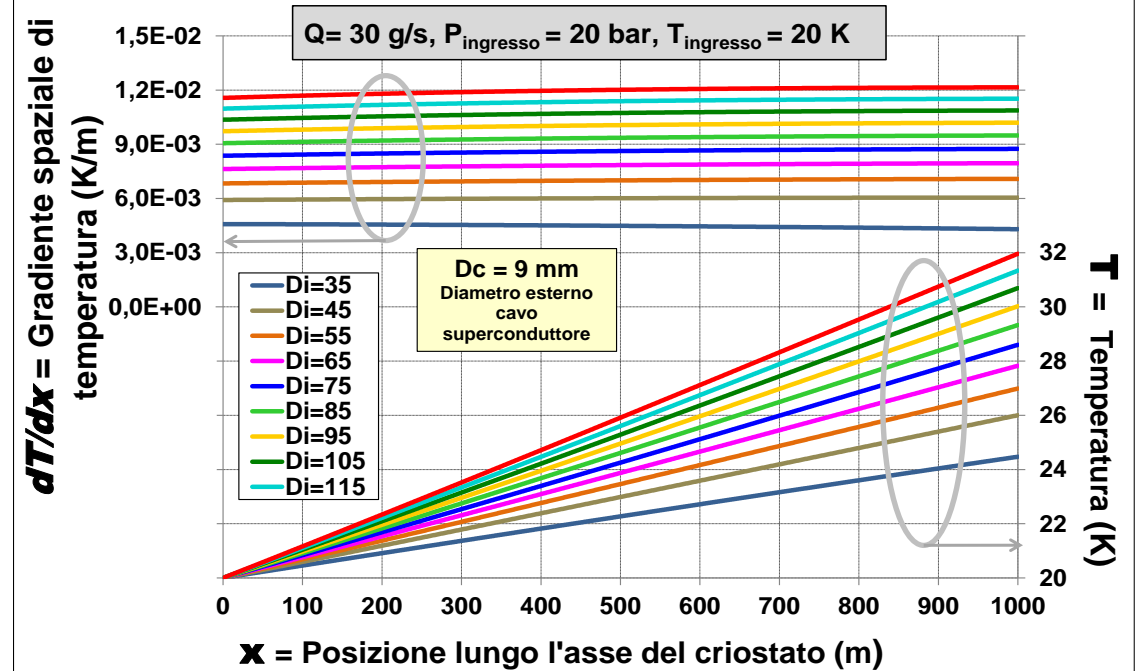




dD/dx e DENSITA' dell'elio in funzione della posizione x , al variare del diametro interno del condotto (D_i in mm)



dT/dx e TEMPERATURA dell'elio in funzione della posizione x , al variare del diametro interno del condotto (D_i in mm)

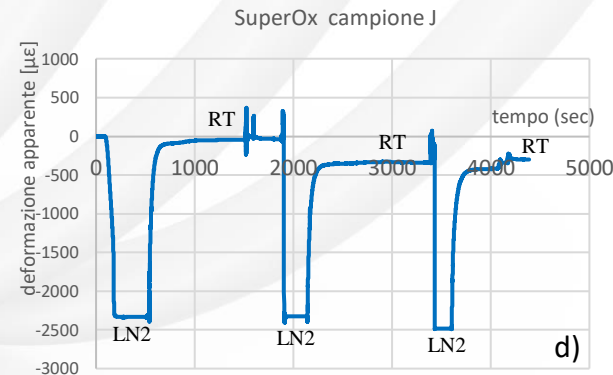
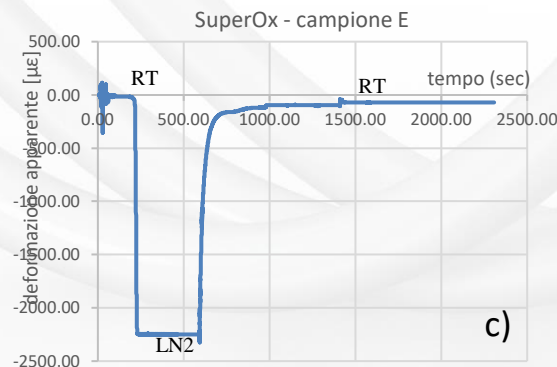
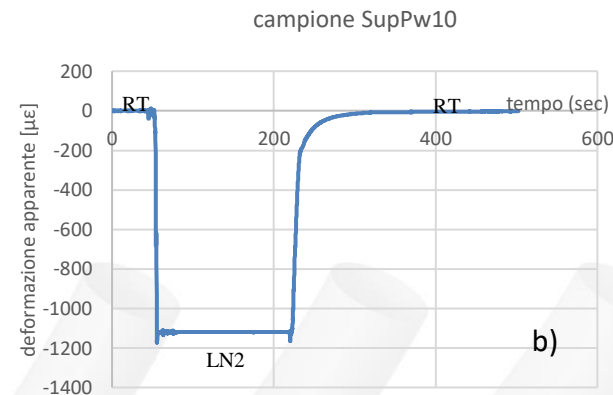
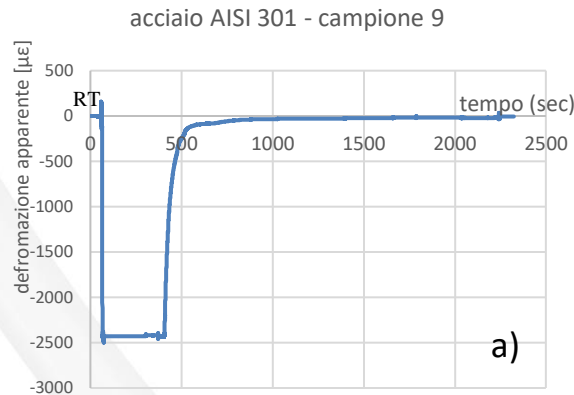


M.Bocchi: Studi e modellazioni per l'analisi del funzionamento e delle possibilità di inserimento di cavi superconduttori in reti elettriche AC e DC: validazione e verifica dei modelli fluidodinamici su nuovi casi studio, sviluppo di modelli per il confronto tecnico-economico con cavi tradizionali (N.Protocollo – 21009207) [RdS Deliverable in Italian]

Italian National Project: Ricerca di Sistema (RdS)

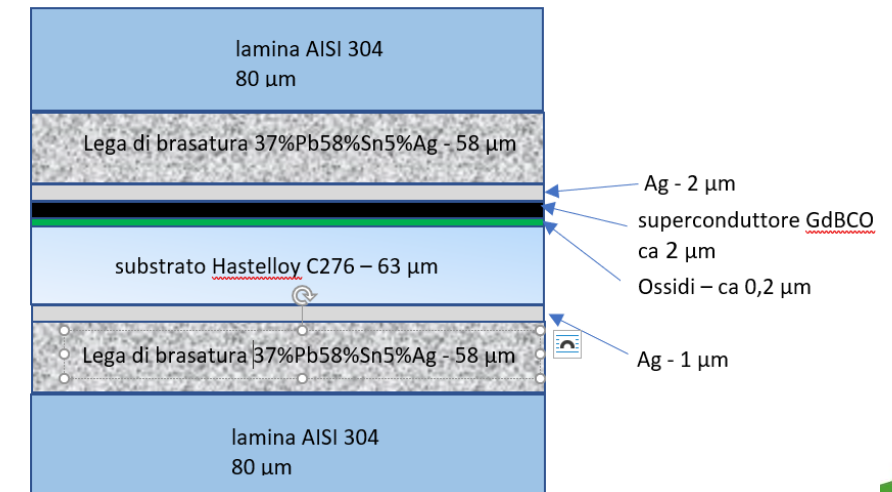
Strain gauge measurements and numerical modelling

- a) **Mechanically elastic tapes:** unwound from the original reel and made horizontal for several seconds, they regain the same radius of curvature.
- b) **Thermally elastic tapes:** brought back by the liquid nitrogen temperature (77 K) to room temperature (RT), they resume their initial curvature, within a certain time interval, thus returning to record zero deformation.



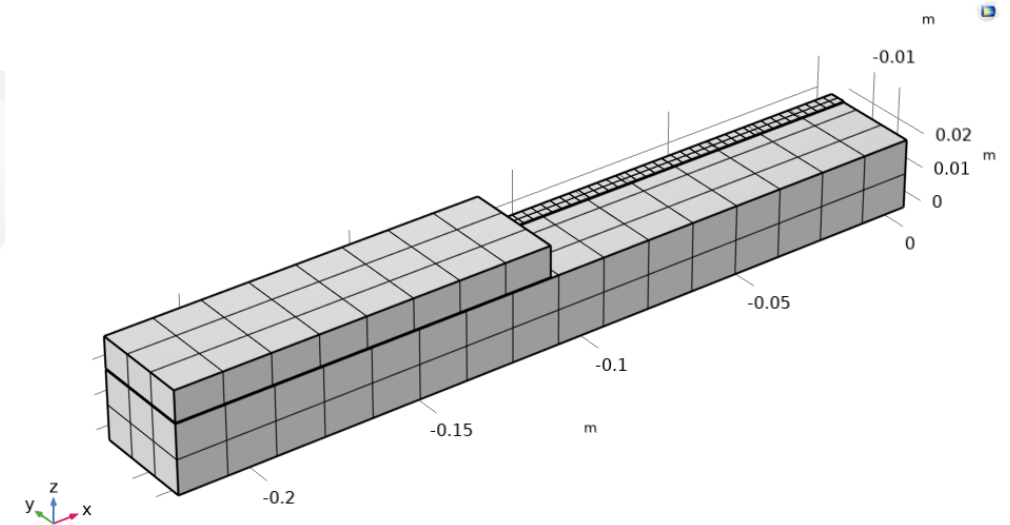
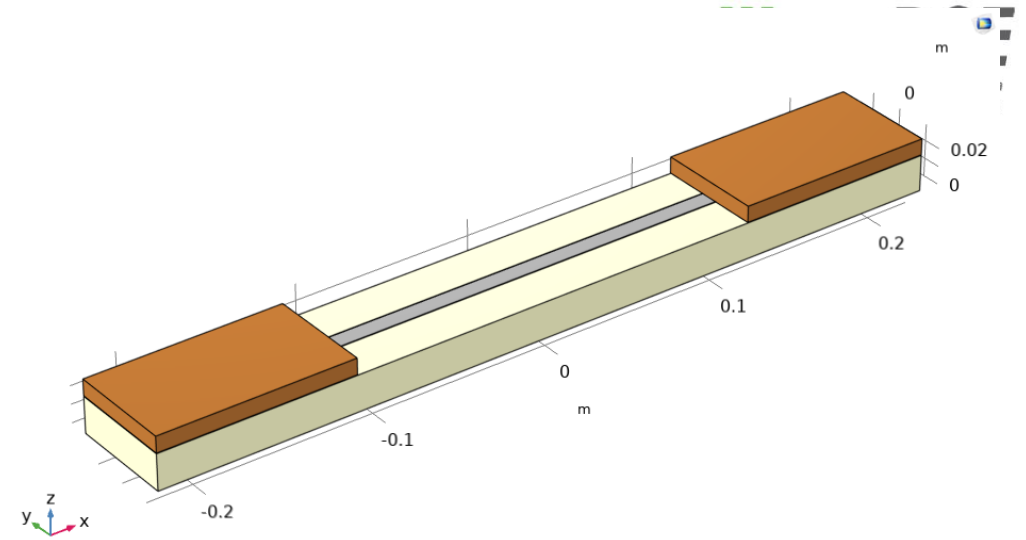
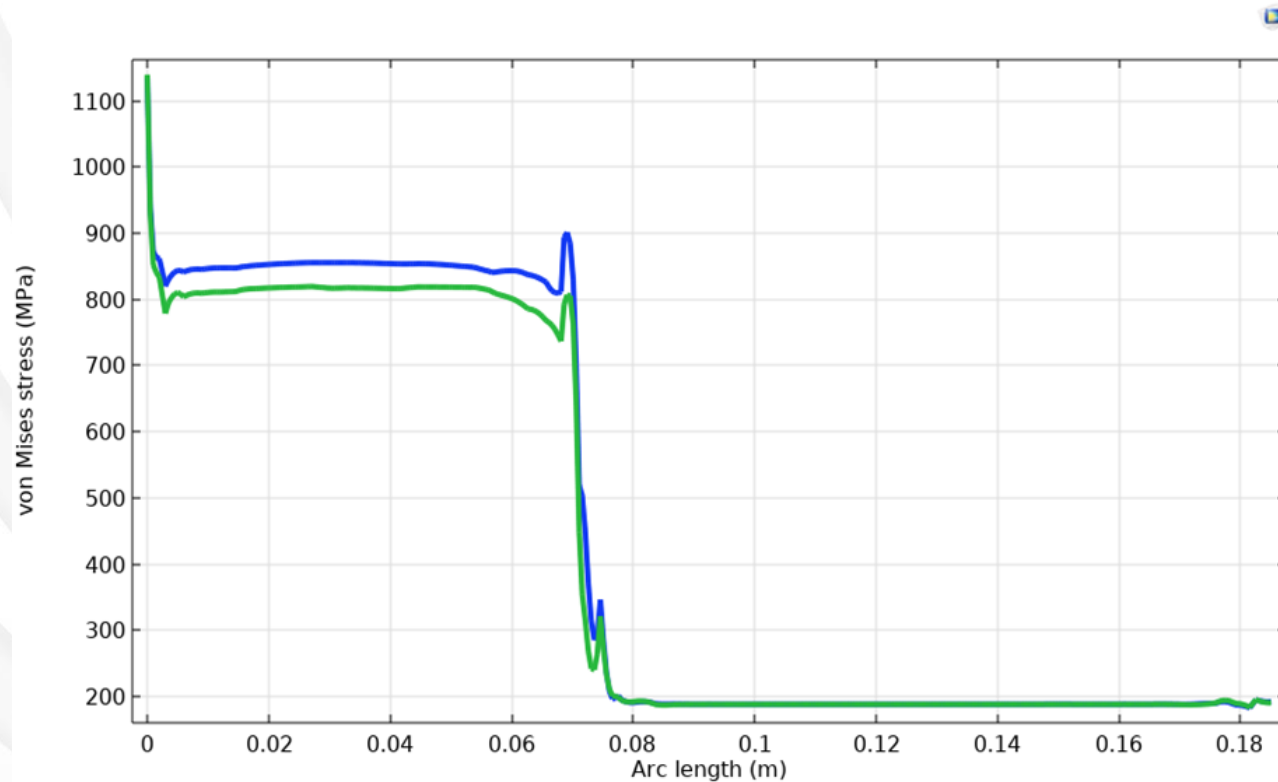
- a) b) : thermally elastic behavior
- c), d) : thermally non-elastic tapes

Cross section of SuperOx tape:



Italian National Project: Ricerca di Sistema (RdS)

COMSOL Multiphysics



The role of HTS research in the Hydrogen PNRR

Superconducting cables cooled-down by liquid hydrogen



- RSE involved in "PNRR - Hydrogen Research - Mission M2-C4 Investment 3.5: Research and development on hydrogen"
- Duration: June 2022-December 2025
- Total funding: around 100M€ - RSE 15M€
- **Proposed activity:** Simulation and technical-economic analysis of systems based on the use of superconducting cables refrigerated with liquid hydrogen for the combined transport of hydrogen and electricity
- **Location:** WP2 - Research and development of solutions for the transportation, distribution and end-uses of hydrogen in natural gas networks
- **Collaborazioni:** University of Bologna, Politecnico di Torino

The purpose of the proposed research activity is to conduct an analysis on the current stage of technological development and on the expected performances of hydrogen-cooled SC cables in order to evaluate the benefits and drawbacks of their use in some representative situations, as well as identify and try to reduce the knowledge gaps in order to have a better understanding of this technology and its uses.

The Infrastructure PNRR: IRIS Proposal



General framework:

- energy transport, medical, power magnets
- Total funding requested around € 100 million
- WP on infrastructure for 1GW SC line (ASG), approximately € 30 million
- INFN (National Institute of Nuclear Physics) Proponent, several co-proponents, RSE can be a "consultant"

Constraints:

- All costs and activities to be carried-out by the end of 2025
- 40% financing to the Southern Italy
- Personnel costs only for permanent contracts carried-out in the project (min 40% women)
- Project Manager to be hired with a European tender

IRIS Innovative Research Infrastructure for applied Superconductivity



Meeting plenario
INFN, Università, CNR-SPIN
RSE, CNAO
Zoom 5 gennaio h 9.30

Missione 4: Istruzione e ricerca
Componente 2: Dalla ricerca all'impresa



Proposal submitted by the Proponent in February 2022
- waiting for feedbacks

The role of Italy (RSE) in the HTS research: the EU Project Fastgrid

Duration: *January 2017 - November 2020*

Coordinator: *CNRS (Francia)*

RSE Role: *WP Leader*

Main goals:

- 1) Development of a **SFCL DC prototype 1kA/50kV** with *quench detection* in optic fiber to be validated by means of dielectric and short-circuit tests
- 2) Development of **innovative conductors based on 2G HTS materials for SFCL devices**, with high uniformity and high electric field (up to 100 V/m per 50 ms)
- 3) Development of **emerging conductors based on 2G HTS materials** with sapphire substrate, with high quench propagation velocity and very high electric field (beyond 100 V/m)

FastGrid



THEVA

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MONTREAL
WORLD-CLASS
ENGINEERING

OXOLUTIA

RSE
Ricerca
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Energetico

CNRS
G2E Lab
Grenoble Ecole Electrique
Grenoble Electrical Engineering

EPFL
ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

RSE
Ricerca
Sistema
Energetico

SuperGrid
Institute

ICMAB
INSTITUT DE CIÈNCIA DE MATERIALS DE BARCELONA
EXCELENCIA
SEVERO
OCHOA
CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS

ELU

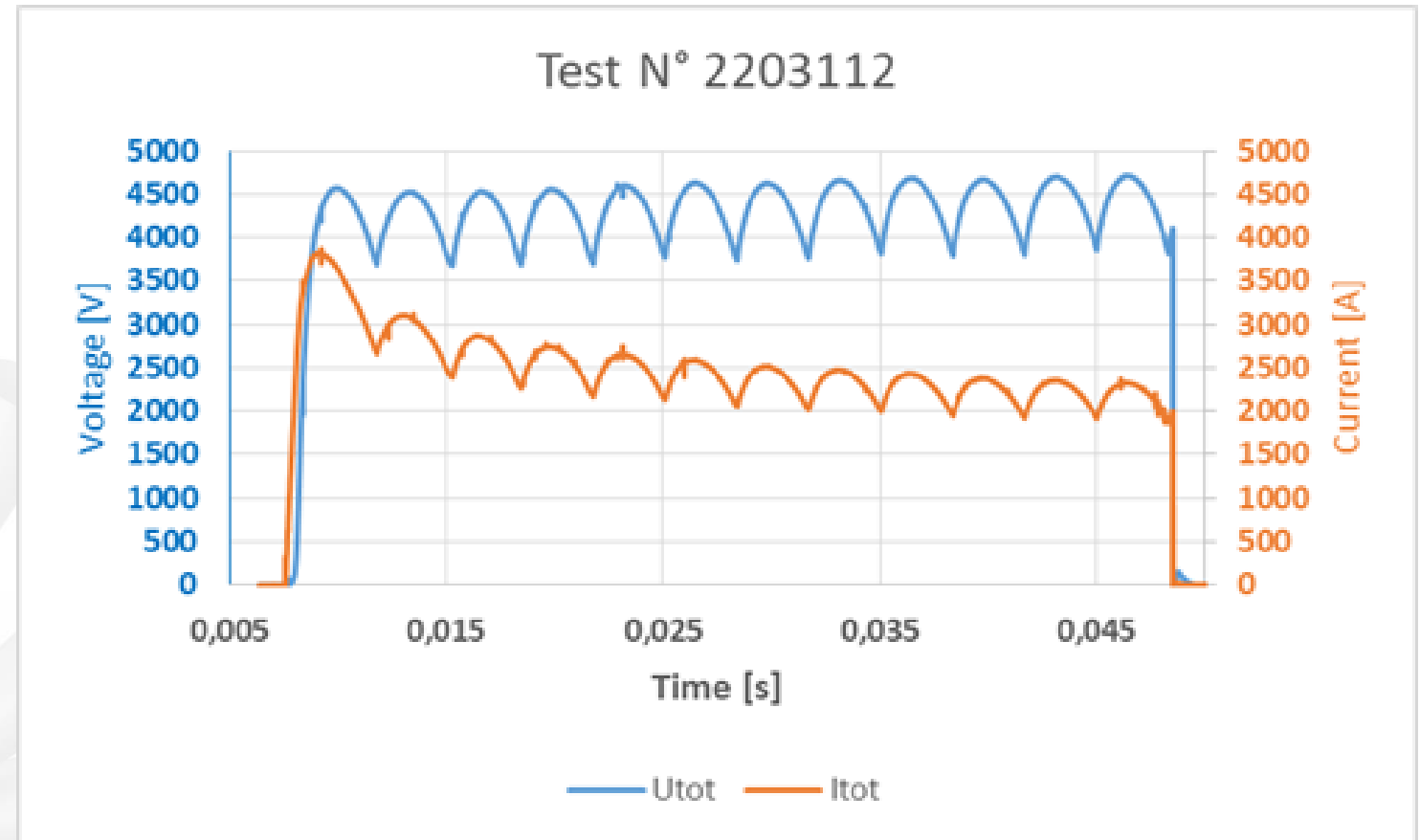
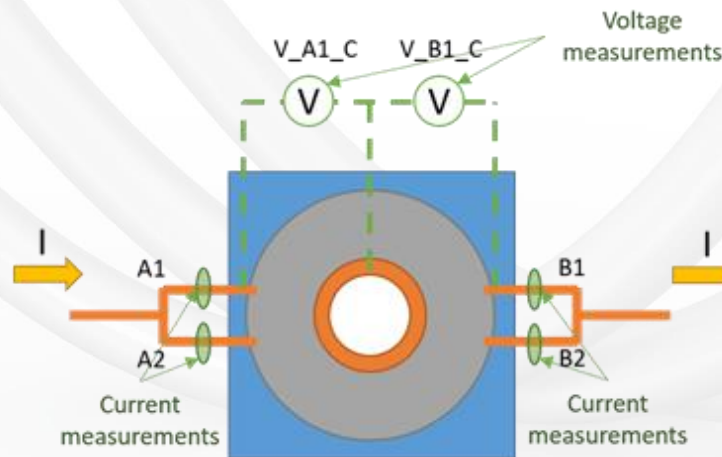
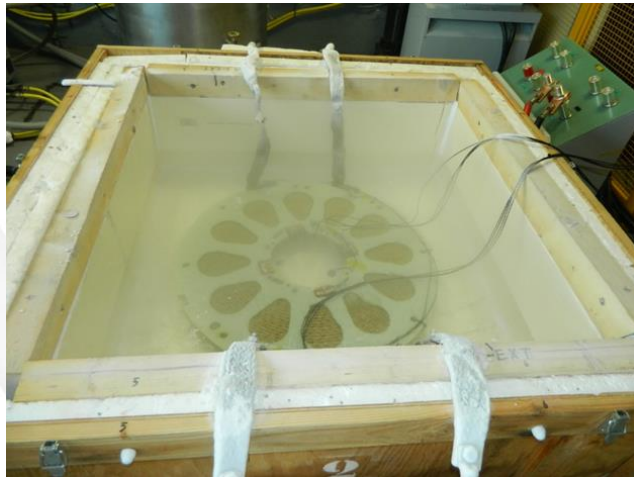
TEL AVIV
UNIVERSITY

The role of Italy (RSE) in the HTS research: the EU Project Fastgrid

Short-circuit tests at the IPH laboratory in Berlin



FastGrid



The role of Italy in the HTS research: the European Project Scarlet

Duration: *54 months*

Coordinator: *SINTEF (Norway)*

4 Italian Partners: *ASG, UniBo, Rina, RSE*

Main goal: to develop **superconducting cables** for the transmission of **DC** power produced from renewable sources both **onshore** and **offshore**

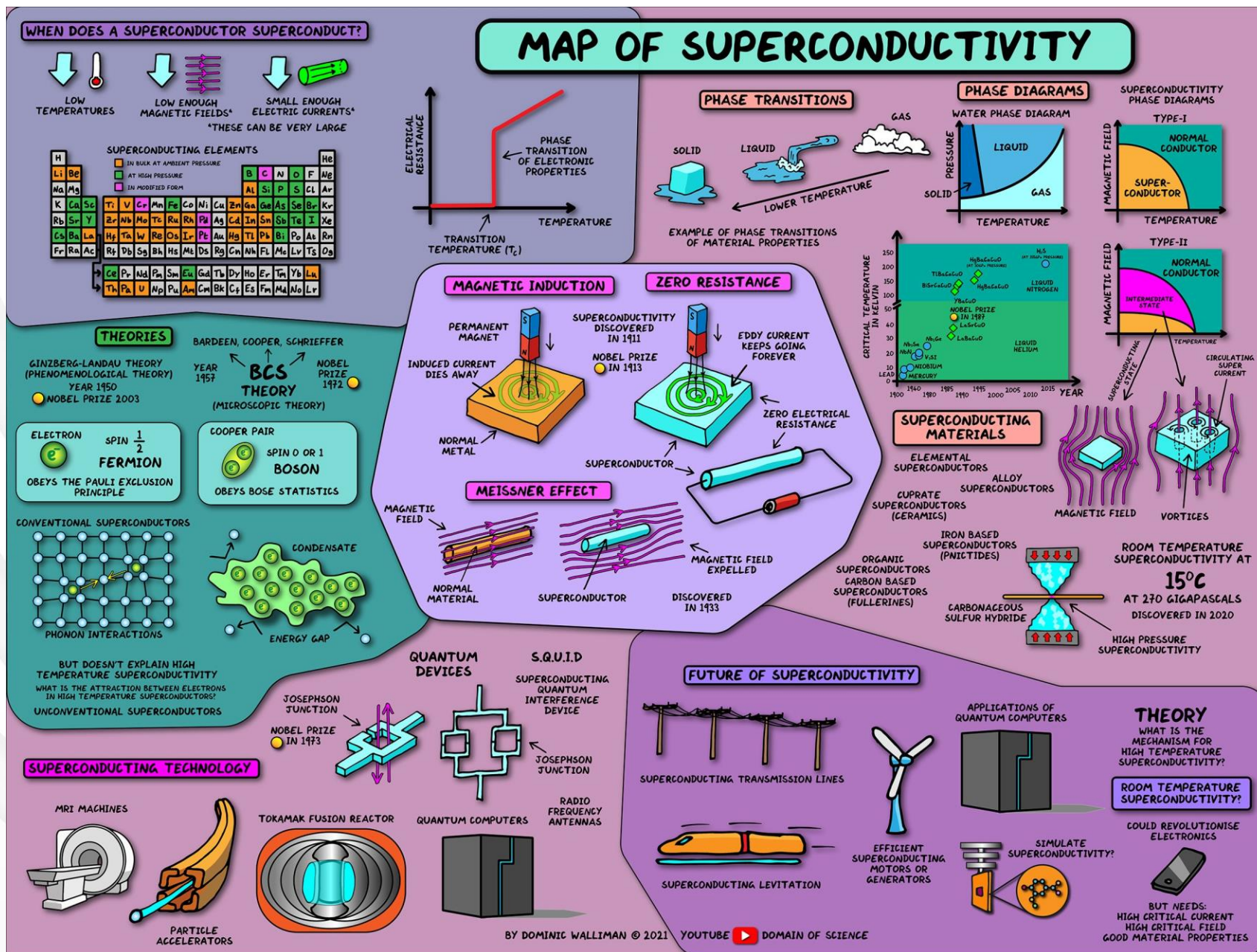
Superconducting cables will be designed considering lengths of several kilometers and will be tested on small-scale prototypes:

- one 1 GW ($\pm 50\text{kV}$ / 10kA) cable based on HTS cooled at 67 K by liquid nitrogen for onshore applications;
- one 1 GW ($\pm 50\text{kV}$ / 10kA) HTS cable for offshore applications;
- one 1 GW ($\pm 25\text{kV}$ / 20 kA) cable in MgB₂ cooled by liquid hydrogen at 20 K for onshore applications.

**ESTIMATED START
SEPTEMBER 2022 !!**

RSE is involved as a partner of the **Work Package (WP) 5**, which is focused on the development of components used for the protection of HTS cables, in particular concerning the **design of a high current SFCL module up to 10 kA in DC**.





*Thanks for
your
attention!!*