Update on the activities on HTS in Switzerland

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ExCo Web-meeting of the IEA HTS TCP

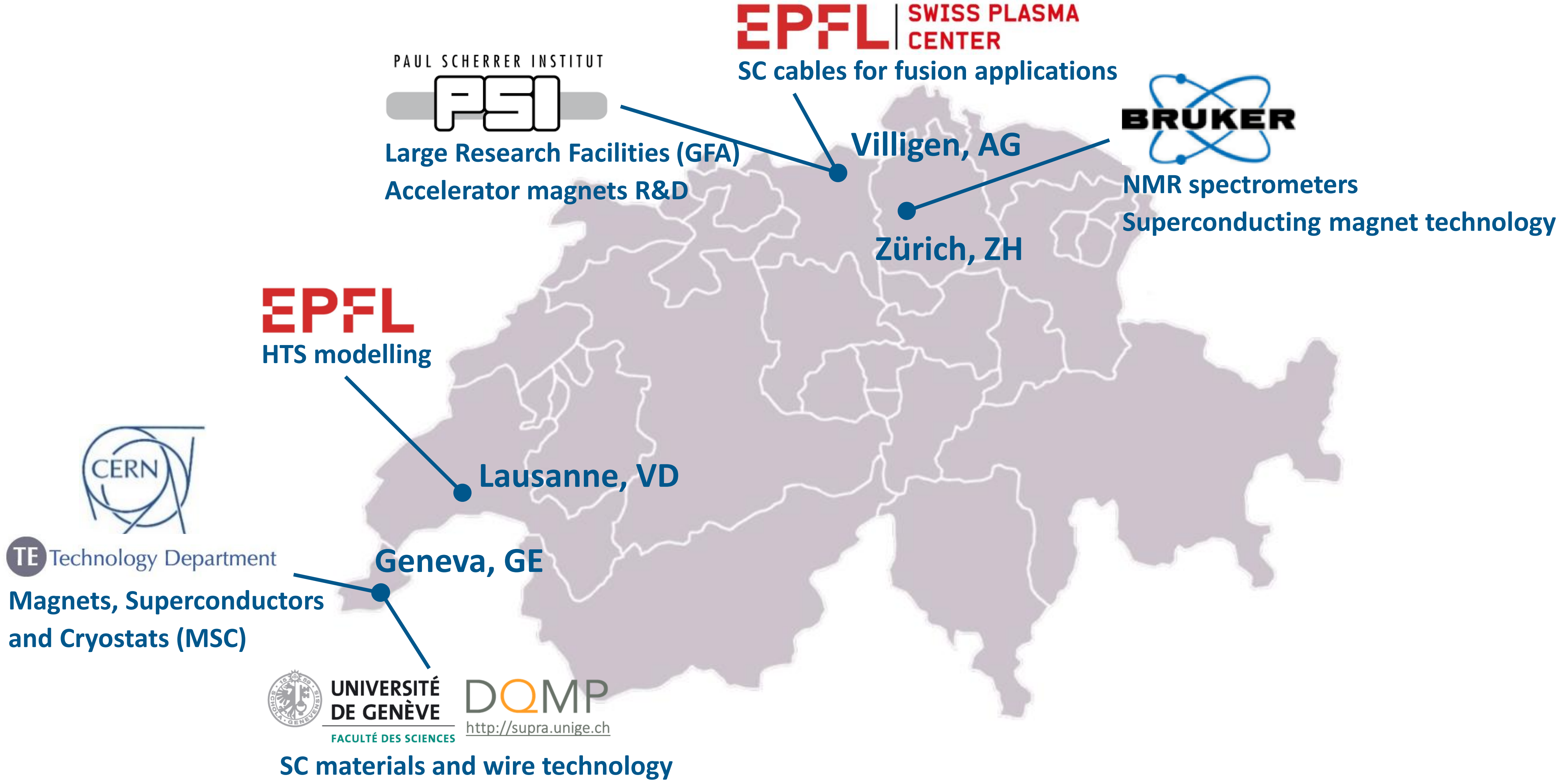
June 9, 2022

Outline

Overview of the activities on HTS R&D at

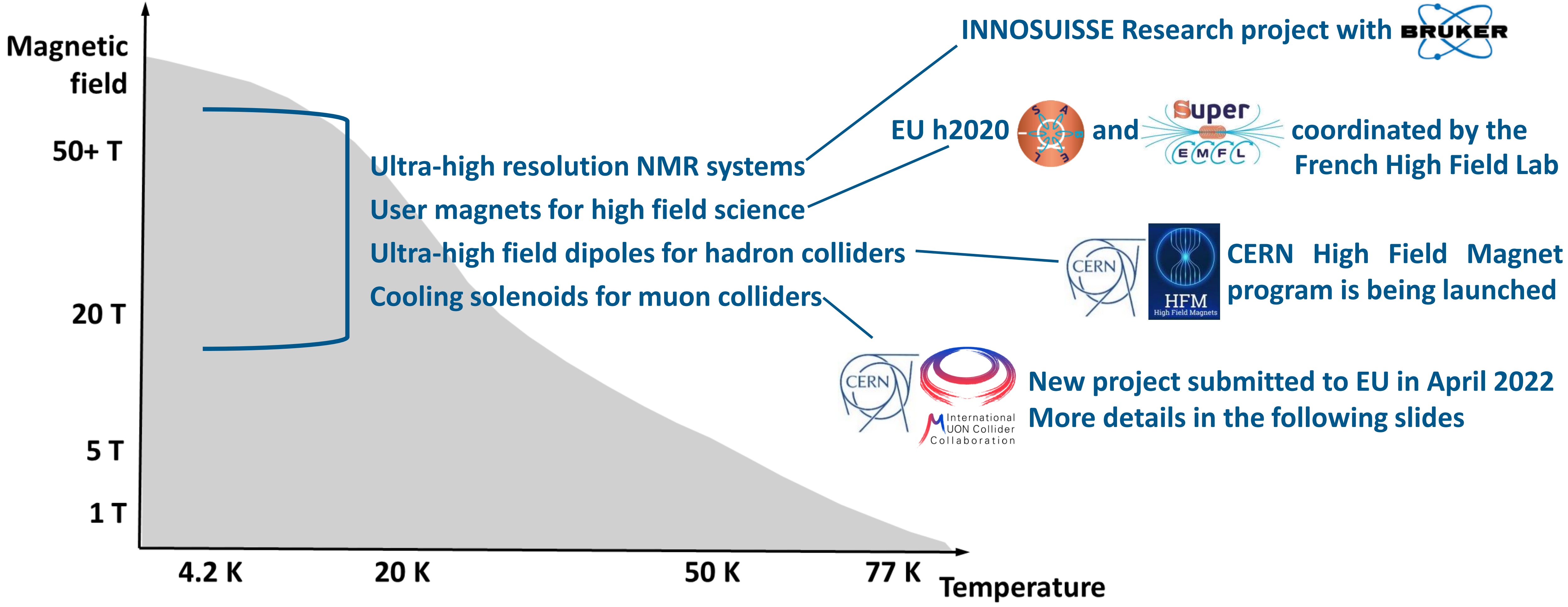
- University of Geneva
- EPFL
  - Swiss Plasma Center (Villigen, AG)
  - Applied Superconductivity Group (Lausanne, VD)
- Paul Scherrer Institute (Villigen, AG)

Applied Superconductivity in Switzerland



Ongoing activities at UNIVERSITÉ DE GENÈVE FACULTÉ DES SCIENCES

The Group of Applied Superconductivity is involved in projects and initiatives for the application of HTS in various domains, from low-temperature/ultra-high field to high-temperature/low-field



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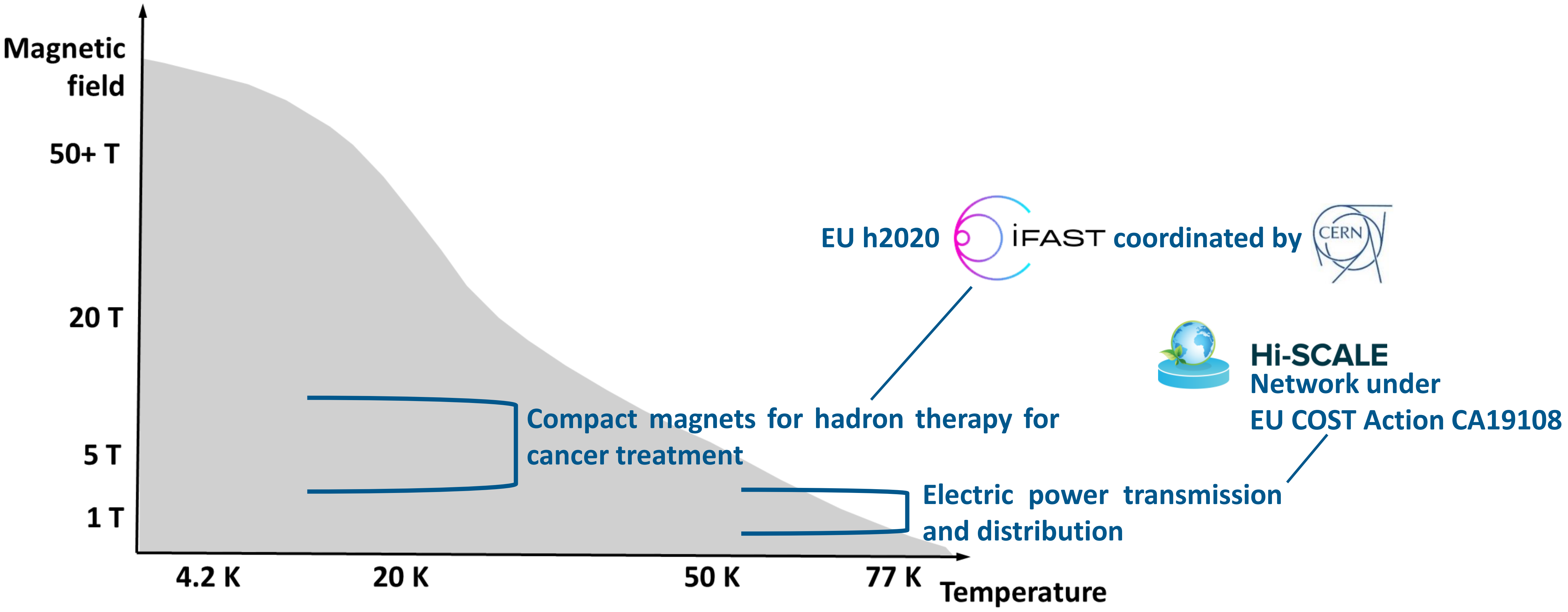
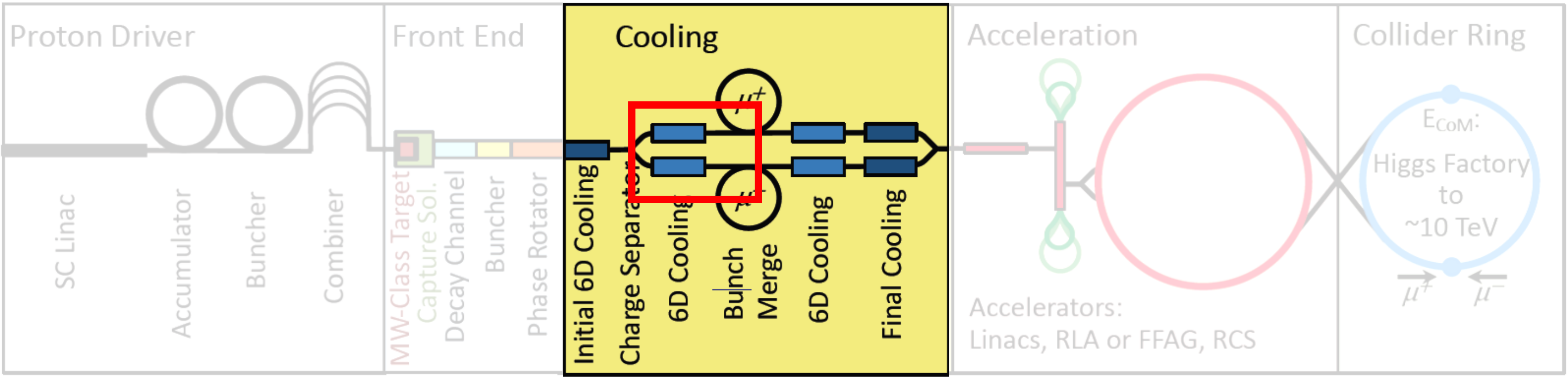


HTS magnets for a muon collider

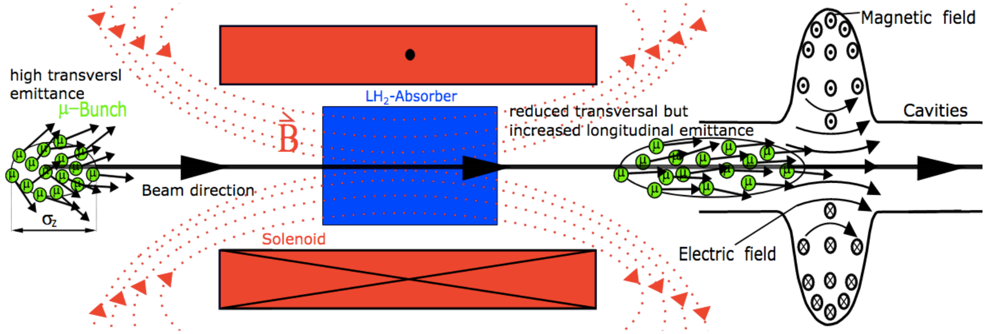
A plan to develop the conceptual design in Horizon Europe

International MUON Collider Collaboration

A Muon Collider is a novel concept of particle collider for searches of new physics based on collisions of muons, particles with a lifetime of 2.2 μs! The short lifetime makes the design very challenging



An entire zoo of superconducting magnets is needed for such a machine



Muons are "concentrated in a beam" through interaction with light matter and subsequent acceleration by radiofrequency.

A field of 40 T to 60 T over a bore of 50 mm, only achievable with HTS, is required to meet the specification

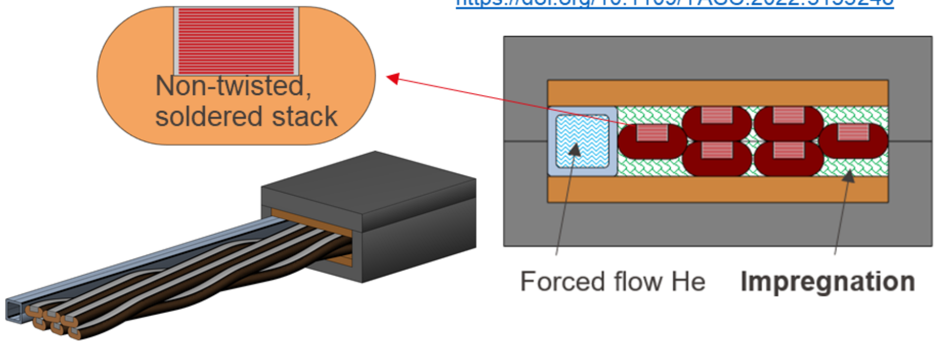
Switzerland is a third country in Horizon Europe. If the project is approved, funding to UNIGE will come from the Swiss State Secretariat for Education, Research and Innovation (SERI)

Ongoing activities at EPFL | SWISS PLASMA CENTER

Non-twisted conductor concepts for DEMO CS

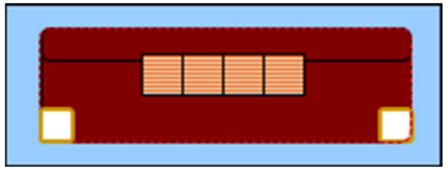
ASTRA (Aligned Stacks Transposed in Roebel Arrangement)

https://doi.org/10.1109/TASC.2022.3153248



- Stack transposition (Roebel cabling) for lower AC loss
- No voids (impregnation of the cable space): strong against transverse compression

Monolithic stack



- The simplest way of assembling tapes in a conductor
- Bendable on small radius
- Largest AC loss, probably not for AC magnets.
- No voids: strong against transverse compression

Two concepts for a non-twisted conductor based on HTS tapes are being developed at EPFL-SPC for the Central Solenoid of the DEMO fusion power plant

Co-wound superconducting wires
https://doi.org/10.1109/TASC.2022.3140706

Optical fibers in the Mach-Zehnder interferometer
https://doi.org/10.1088/1361-6668/abb200

Tests for advanced quench detection in non-twisted stack samples are being performed using co-wound superconducting wires and optical fibers in the Mach-Zehnder interferometer (Patent of Akbar and Dutoit)

Courtesy of K. Sedlak, D. Uglietti, N. Bykovskiy, R. Sobota, P. Bruzzone

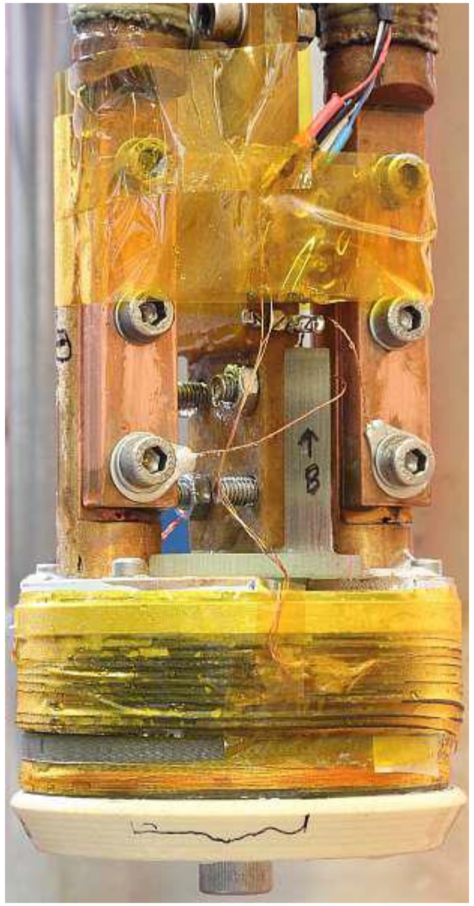
Ongoing activities at EPFL SWISS PLASMA CENTER BRUKER

Bi-2212 insert for high field NMR magnets

An Innosuisse project in a collaboration between EPFL-SPC and Bruker Biospin is running with the goal of developing Bi-2212 high field inserts for NMR magnets

The project goal is to integrate overpressure heat treatment to reach high current density with a thin electrical insulation and winding pack reinforcement for application in NMR magnets.

A first intermediate objective has been achieved: engineering current density in Bi-2212 wire exceeding 600 A/mm^2 at 15 T, 4.2 K at hoop stress levels well above the mechanical limit of the Bi-2212 wire itself.

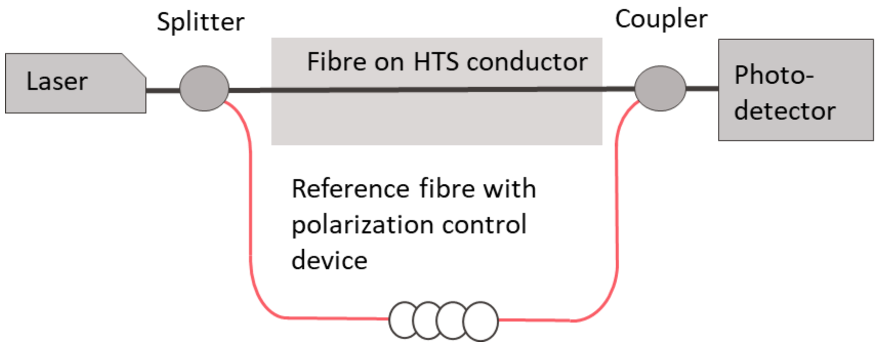


Courtesy of K. Sedlak, D. Uglietti, N. Bykovskiy, R. Sobota, P. Bruzzone

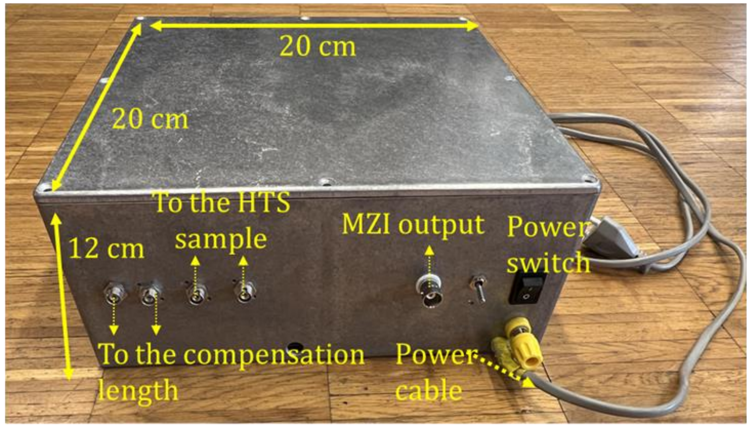
Ongoing activities at EPFL Applied Superconductivity Group

Fast hotspot detection in HTS applications by Optical Fiber Sensing combined to Machine Learning

The Mach-Zehnder Interferometer (MZI) schematic



The compact MZI plug-and-play box for HTS monitoring



- During a hotspot the changing light path on the fiber attached to the superconductor induces rapid change in phase that manifests as amplitude change between 0 and 1 in the Mach-Zehnder interferometer (MZI) output
- Single hotspots have been detected in up to 17 m of HTS conductor length in a SFCL pancake within 10 ms
- The entire setup is assembled in a compact plug-and-play box where the HTS sample can be connected for health monitoring
- The result was patented: International patent WO 2021/038505 A1
- A machine learning based classification technique has been developed to process the MZI output. This prevents false alarms when using MZI for quench detection, with an accuracy > 94%

Courtesy of A. Akbar, B. Dutoit

Ongoing activities at EPFL Applied Superconductivity Group

3rd International School on Numerical Modelling for Applied Superconductivity in Saas Fee, Switzerland, 6-10 June 2022

EPFL

SAAS-FEE, SWITZERLAND

JUNE 6TH – 10TH 2022

Principal Lecturers

- Dr. Mark Ainslie, University of Cambridge,UK
- Dr. Satoshi Awaji, Tohoku University, Japan
- Dr. Arnaud Badel Tohoku University, Japan
- Dr. Bernardo Bordini, CERN, Switzerland
- Dr. Luca Bottura, CERN, Switzerland
- Dr. Marco Breschi, University of Bologna, Italy
- Dr. Guillaume Dilasser, NeuroSpin, France
- Dr. Marc Dhalle University of Twente, Netherlands
- Dr. Cristophe Geuzaine, University of Liège,Belgium
- Dr. Francesco Grilli, KIT, Germany

Contents

1. Superconductor modelling
2. Design principles, FEM, and numerical methods
3. Electro-thermal and Electro-magnetic aspects for HTS and LTS
4. Mechanics in superconducting magnets

A hands-on summer school

Design a hybrid high-field superconducting magnet

Lectures will be followed by computer based exercises, learn through interesting practical exercises in state-of-the-art software

The school is organized by Bertrand Dutoit who is going to retire at the end of summer 2022

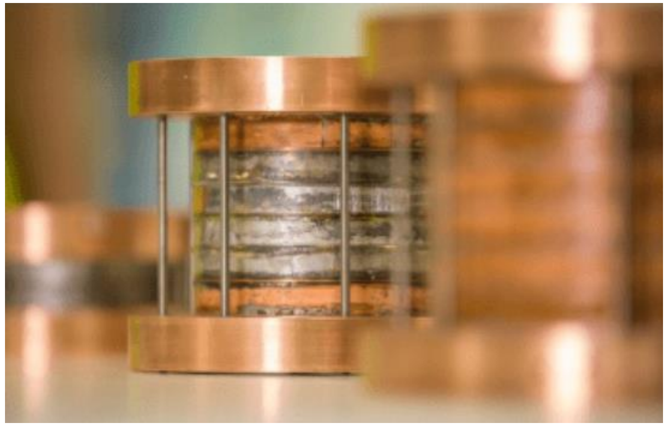
Ongoing activities at PSI

PAUL SCHERRER INSTITUT

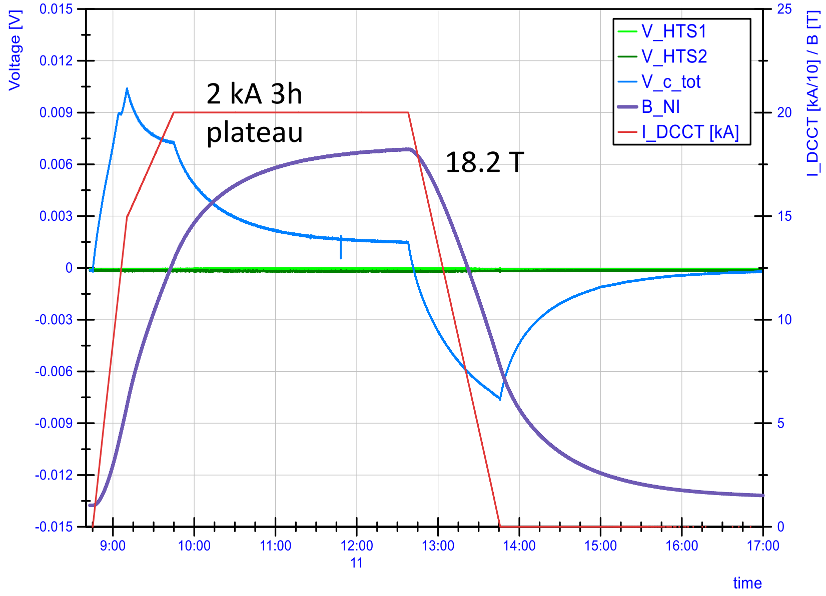
CHART
Swiss Accelerator Research and Technology
https://chart.ch/

Successful test of a 18 T HTS solenoid

The Paul Scherrer Institute entered into a collaboration with tokamak energy for the use of Tokamak Energy's proprietary non-insulated (NI) high temperature superconducting (HTS) magnet technology.
https://chart.ch/2021/02/17/collaboration-tokamak-energy/



In the frame of CHART, which is the Swiss collaboration on Accelerator Research and Technology, an HTS solenoid was built and achieved 18.2 T in a 5-cm bore, corresponding to 20.3 T on the conductor. The field was achieved in a cryogen-free conduction cooled setup, operating at 2 kA and 12 K.



Courtesy of B. Auchmann

Thank you for the attention !

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