SUPER CONDUCTIVITY
International Energy Agency

High Temperature Superconductors

Activities in Switzerland

ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

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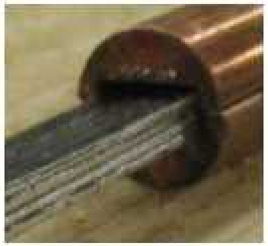
SWISS Plasma Center

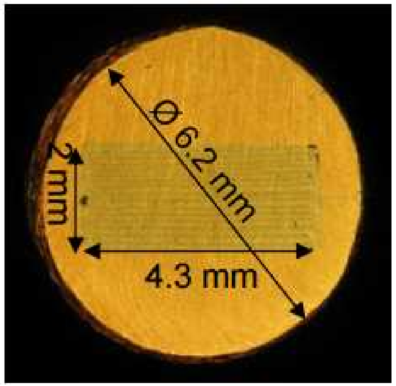
- Work performed at PSI in Villigen by
  - R. Wesche, N. Bykovsky, K. Sedlak,
  - B. Stepanov, D. Uglietti, P. Bruzzone
- SULTAN and EDIPO test facilities:
  - high current, force flow conductor tests

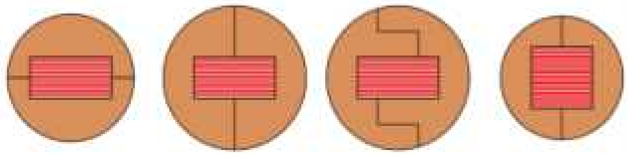
	EDIPO	SULTAN
Maximum DC field	12.35 T	10.89 T
DC field length (±1%)	910 mm	425 mm
Sample size in test well	89 mm x 138 mm	92 mm x 142 mm
Maximum sample current	> 100 kA	> 100 kA
Temperature operating range	4.4 K – 60 K	4.4 K – 10 K
Available flux in transformer	2.97 Vs	1.65 Vs

SWISS Plasma Center

- 60 kA HTS cable was designed and manufactured at SPC
  - Features of conductors for Fusion Magnets
    - Peak field in the 10 T □ 20 T range.
    - Large bending radius (> 3 m) during winding.
    - Very large current (>40 kA) and large Cu cross section (500 to 900 mm2), thus low Je .
    - Moderate AC losses.
    - Cheap and easy industrial production (> 1 Km).
    - Large transverse loads (steel structures takes up all the Hoop stress).







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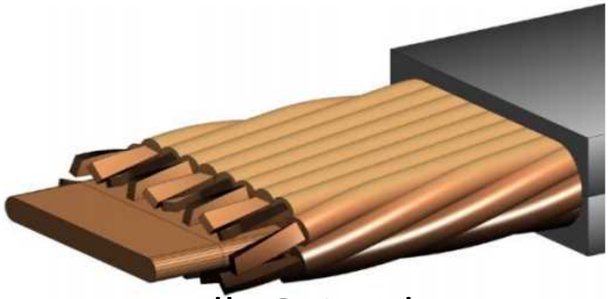
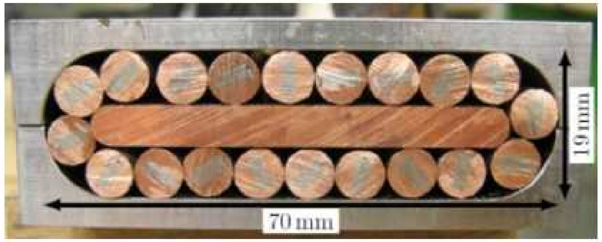
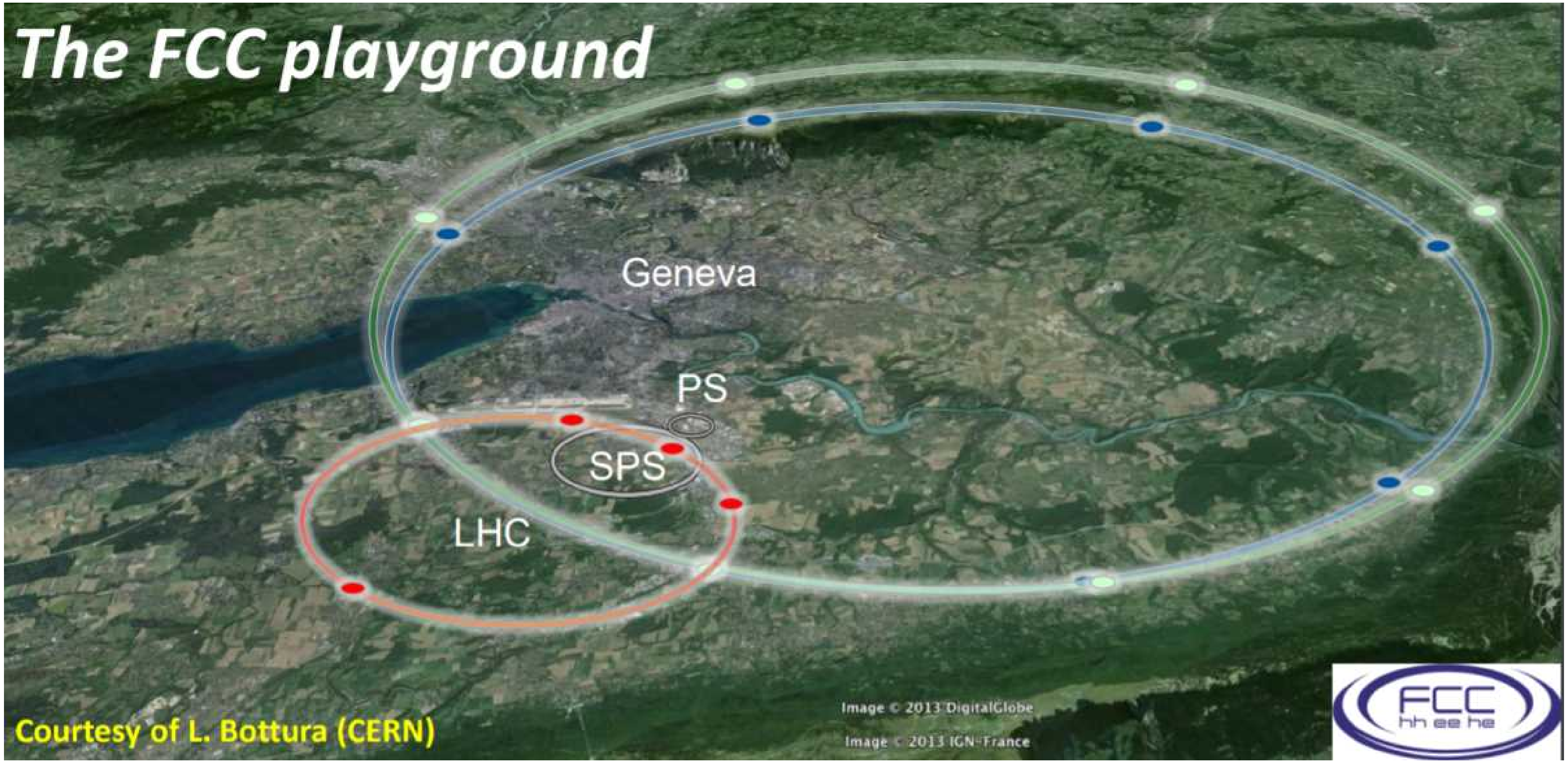
	Tot cross section (without jacket)	*Tot. copper cross section*	*Void fraction*	*Operating current and field*	*T_{cs} at operating conditions*	*Operating current density (non Cu)*
ITER TF (Nb_3Sn)	**1250 mm²**	515 mm²	32%	68 kA, 11.1 T	5.8 K to 7.0 K	**280 A/mm²**
DEMO TF (Nb_3Sn)	**1220 mm²**	675 mm²	23%	82 kA, 13.4 T	about 6.5 K	**300 A/mm²**
HTS prototype	**1250 mm²**	760 mm²	32%	50 kA, 12 T 30 kA, 12 T	8 K 21 K	**500 A/mm²** **300 A/mm²**





- Recent talk @ SPC by Dr. M. Greenwald, PSFC-MIT, Boston, USA:
  - The high magnetic field path to practical fusion energy
- "The emergence of high-temperature superconductors (HTS) as an industrially mature product opens up a new path to practical fusion energy enabling more compact, less expensive fusion devices"
- https://phys.org/news/2015-11-breakthrough-superconducting-materials-path-fusion.html

The future at CERN



LHC	HE-LHC	FCC-hh	FCC-hh
27 km, 8.33 T	27 km, 20 T	80 km, 20 T	100 km, 16 T
14 TeV (c.o.m.)	33 TeV (c.o.m.)	100 TeV (c.o.m.)	100 TeV (c.o.m.)
1300 tons NbTi	3000 tons LTS	9000 tons LTS	6000 tons Nb_3Sn
	700 tons HTS	2000 tons HTS	3000 tons NbTi

Applied Superconductivity @ UNIGE, Prof. C. Senatore

- Sophisticated low temperature/ high field measurement techniques
  - High magnetic fields: 21 Tesla
  - Electromechanical properties under axial and transverse loads
  - Specific heat and thermal conductivity
  - Magnetic properties
- Top facilities for material synthesis
  - Pulsed Laser Deposition of thin films
  - Machines for metallurgy and powder-metallurgy
  - Various controlled atmosphere furnaces
  - All the equipment for the development of superconducting wires

UNIGE & Bruker, June 8th 2016

- 1st 25 T fully superconductive magnet in Europe
- 25 T with REBCO in a 21 T LTS outsert

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BRUKER

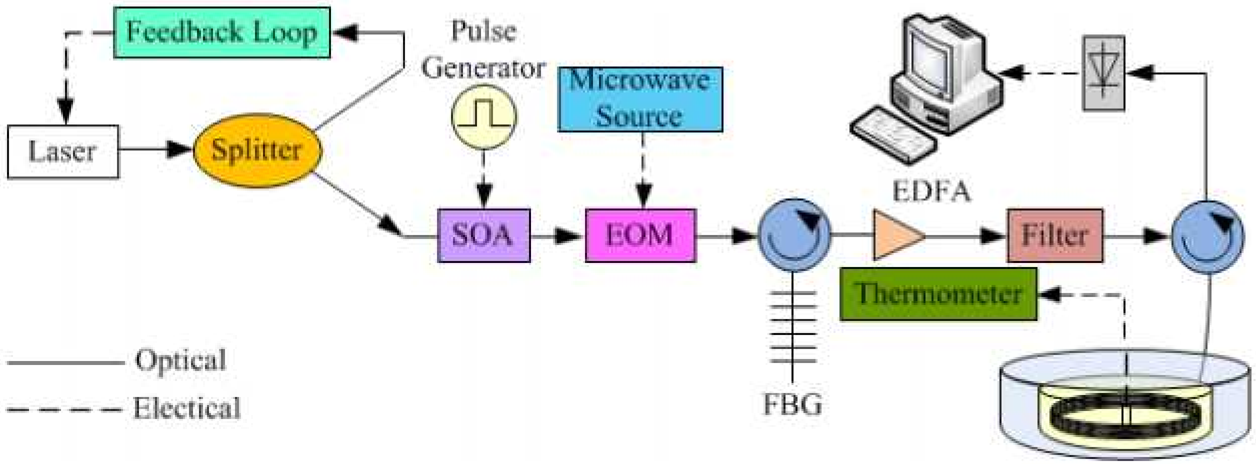
MaNEP

- Materials with Novel Electronic Properties
  - http://www.manep.ch/
  - Fundamental understanding and control of the electronic properties of new materials
  - Effort to transfer its technology to industrial applications
  - **SUMMER INTERNSHIPS**
  - https://www.manep.ch/education/summer-internships/

- SWM 2016 http://www.manep.ch/swm16
  - July 2016, Les Diablerets
  - Applications was one topic of the conference

EPF Lausanne, GFO, Prof. Luc Thevenaz

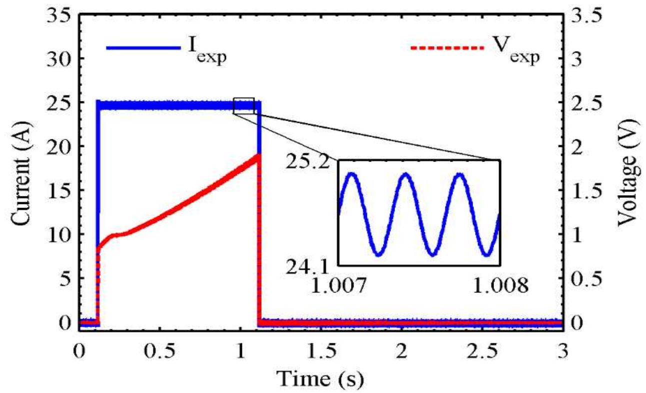
- Specialist in Optical fibre sensing
- Project: Investigation of Distributed SensingTechniques Based on Fibre Optic Technology and Their Applicability to ITER for Leak Localisation
- Method: Coherent Rayleigh scattering
- Achievement: MilliKelvin resolution in cryogenic temperature distributed fibre
- sensing based on coherent Rayleigh scattering
- Range: 77 – 300 K

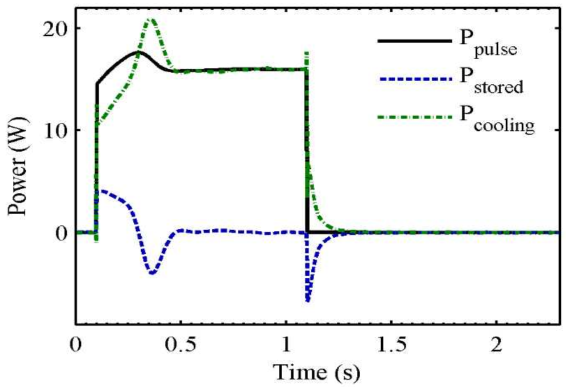


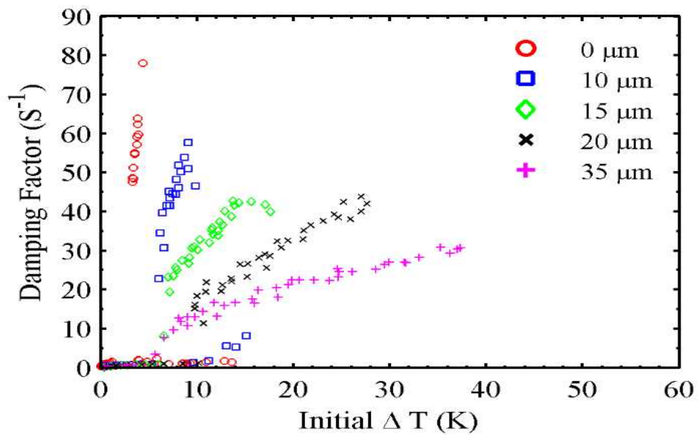
- Will be used for Quench detection (Prof. Justin Schwartz work on it in the US)
- Is developped within FASTGRID project

EPF Lausanne

- Real time Heat Transfer Monitoring Between Quenched High-Temperature Superconducting Coated Conductors and Liquid Nitrogen





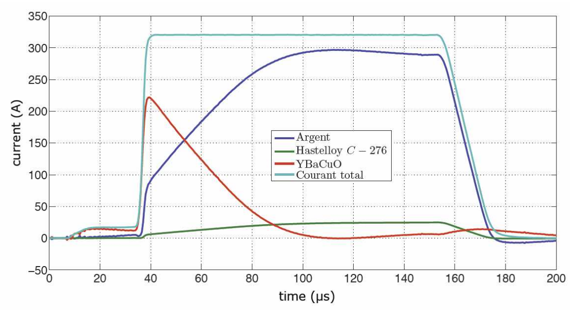


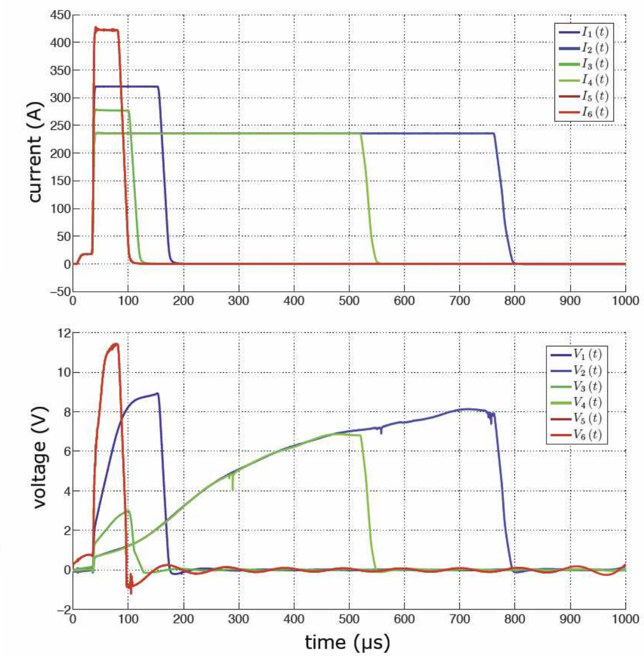
- Background idea: Better stability in several applications, faster recovery in FCL can be achieved using optimized thermal insulation.

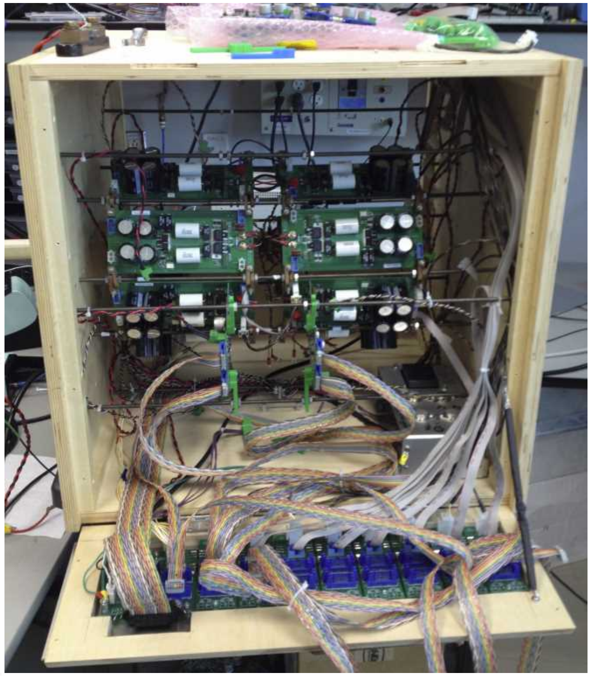
EPF Lausanne together with EP Montréal

- Goal: Almost isothermal V(I,B) measurements -> fast measurements
- 2G HTS coated conductors measured with microsecond range pulsed currents
- Unique: 0 – 1000 A in < 3 µs
- Up to 16 * 200A modules with local MCU

- Current sharing:







- Current density (and temperature) are NOT uniform in tape cross-section
- Analyzing experimental results with finite elements is required in order to understand the physics and get the correct parameters

Lausanne 1st Summer School June 2016

- Hands on
- Fantastic teachers from
  - CERN
  - Twente
  - KIT
  - Houston
  - Grenoble
- 32 students
- From 15 different countries
- A great success
- Next School In Lisboa PT
  July 2-6th 2018

See you in Geneva !

EUCAS 2017

GENEVA

17 - 21 September 2017

CERN

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