Hot-Spot Temperature Experiment

Chats Workshop
10th October 2013

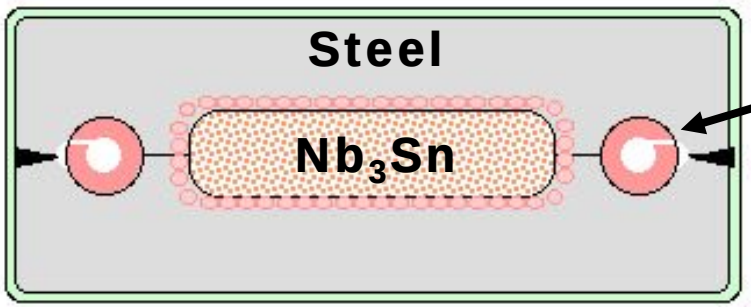
Kamil Sedlak, Pierluigi Bruzzone
EPFL-CRPP, Villigen, Switzerland

CRPP

ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

Motivation for the Hot-Spot Experiment

- A new superconducting cables are being designed for the (EFDA) DEMO fusion reactor (tokamak).
- The “react and wind” option could look like this:



Cooling channel

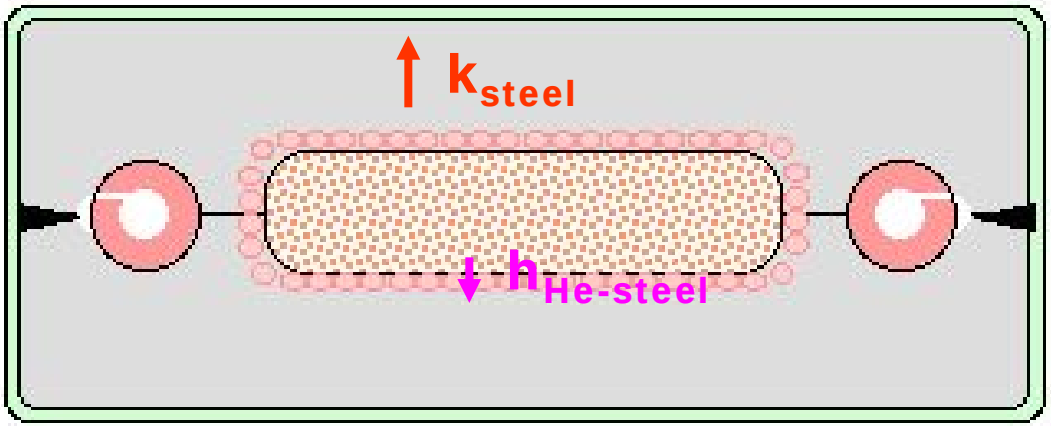
Cond. size = 113x45 mm^2
I_{op} = 82.4 kA
T_{op} = 4.5 K

- Important for hot-spot temperature during a “quench”:
  - Current decay time during fast discharge τ= 23 s.
  - Massive stainless steel conduit.

➔ Steel can certainly absorb a big fraction of heat during a fast safety discharge. How much?

Motivation for the Hot-Spot Experiment

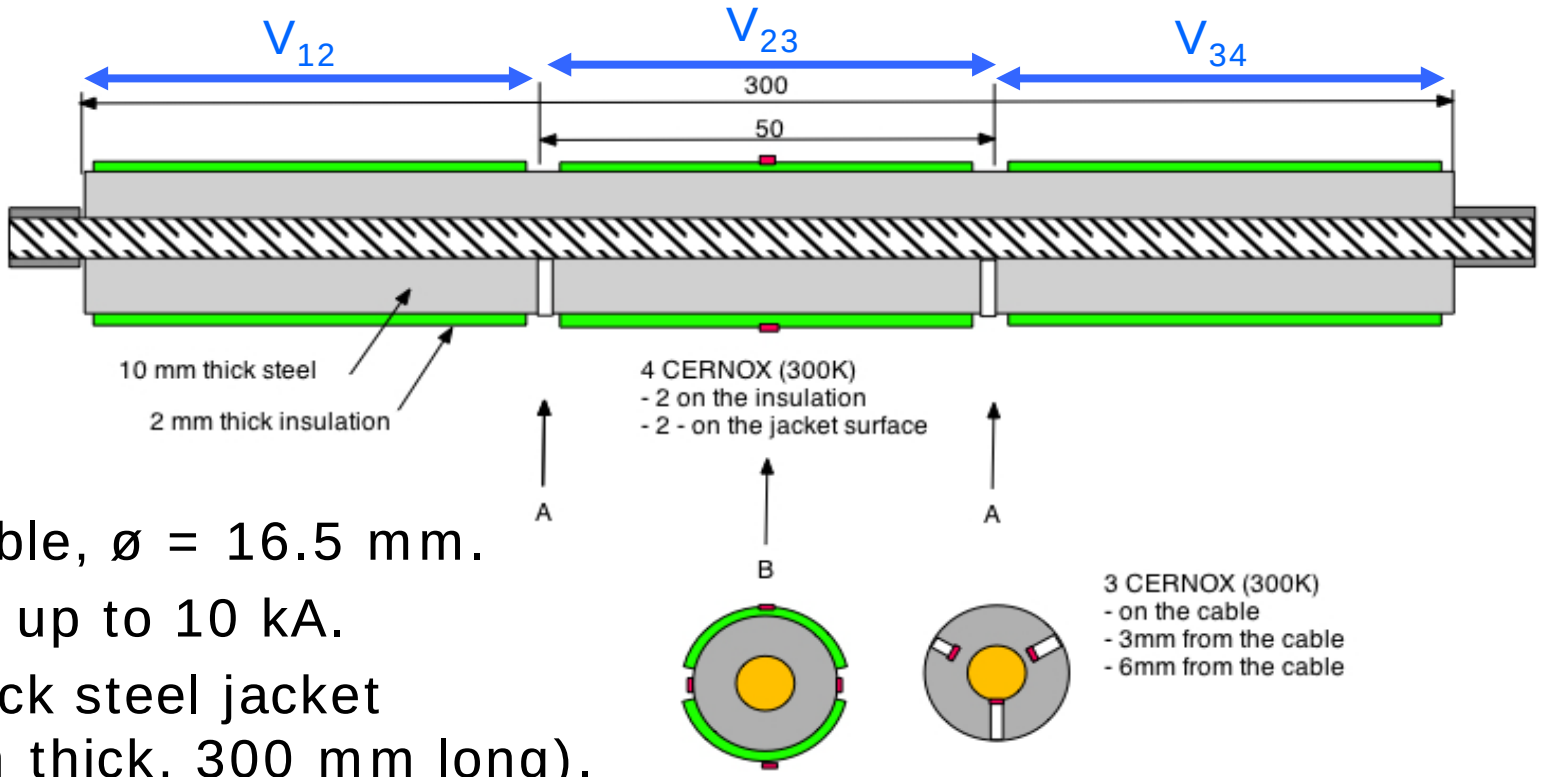
- The Hot-Spot experiment should
  - become a bench mark experiment for validation of simulation tools used for DEMO cable assessment.
  - give us some basic parameters, e.g. heat transfer coefficient ($h_{He\text{-}steel}$) between helium and steel.



k_{steel} … heat conductivity (known and tabulated as function of T for different kinds of steel).

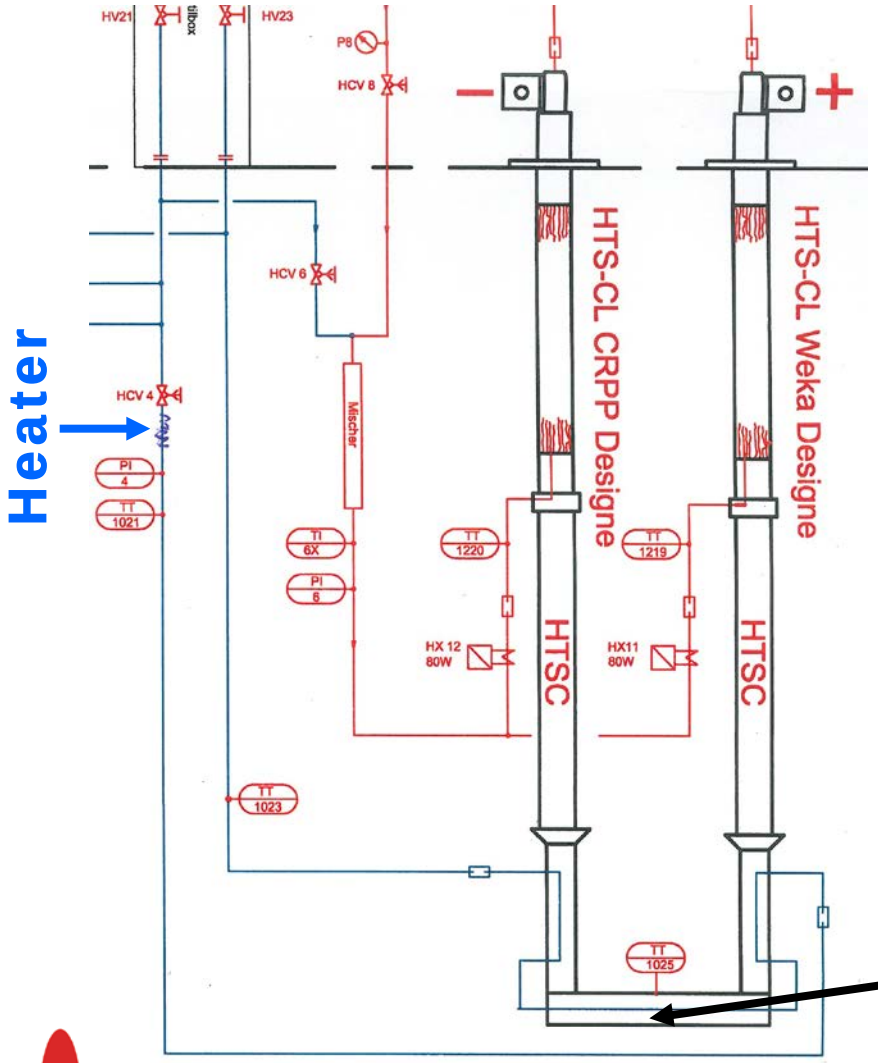
$h_{He\text{-}steel}$ … heat transfer coefficient on the boundary – unknown at high (~100 K) temperatures

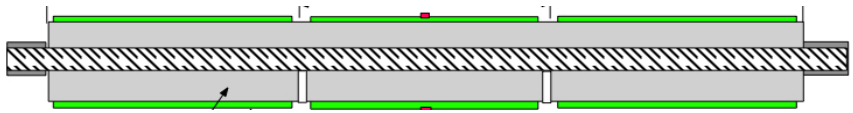
Experimental Setup



- NbTi cable, ø = 16.5 mm.
- Current up to 10 kA.
- New thick steel jacket (10 mm thick, 300 mm long).
- Quench should be initiated in a damaged location in the centre of the cable.
- Goal: Achieve hot-spot temperature > 100 K.

Experimental Setup

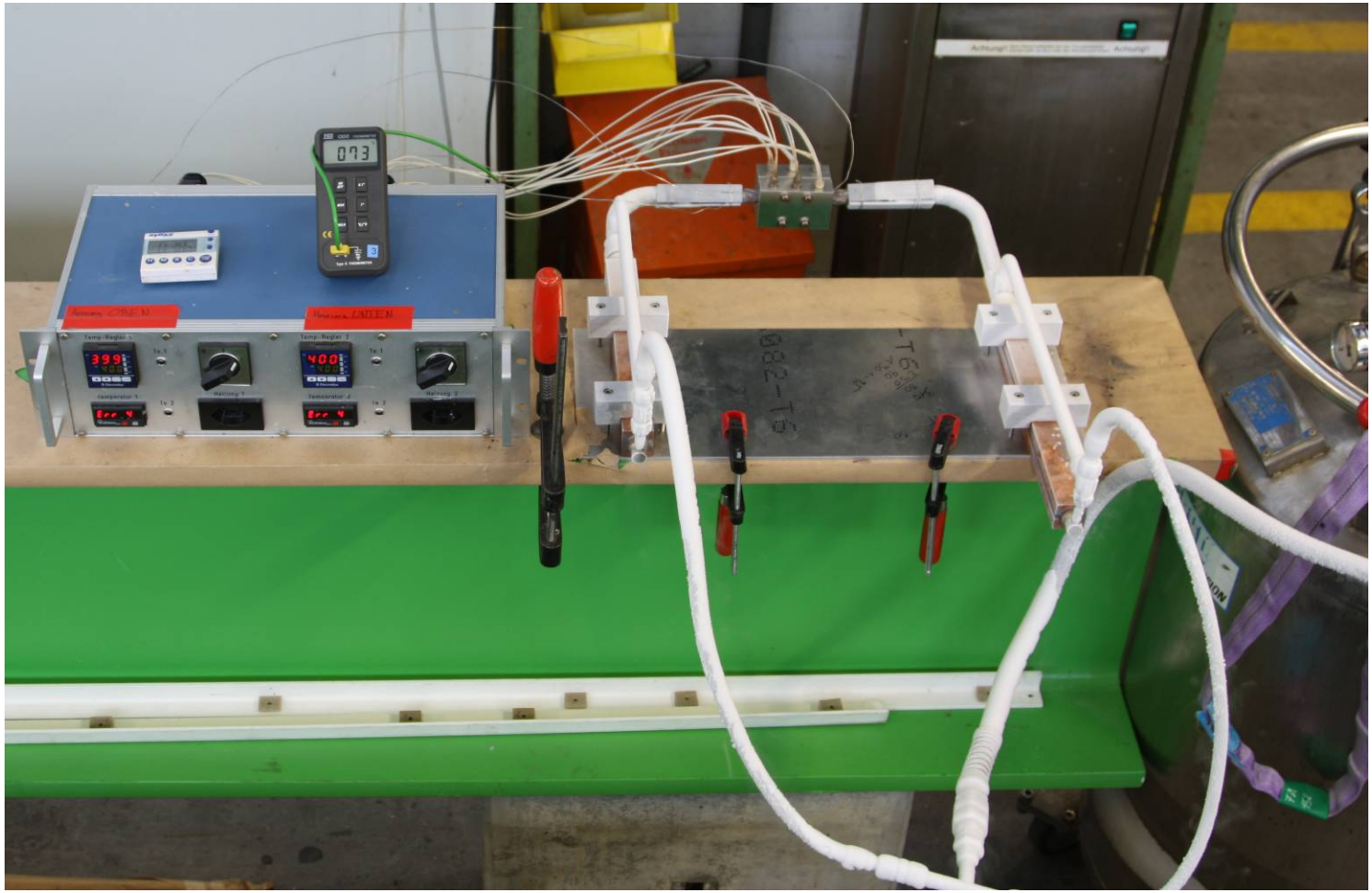




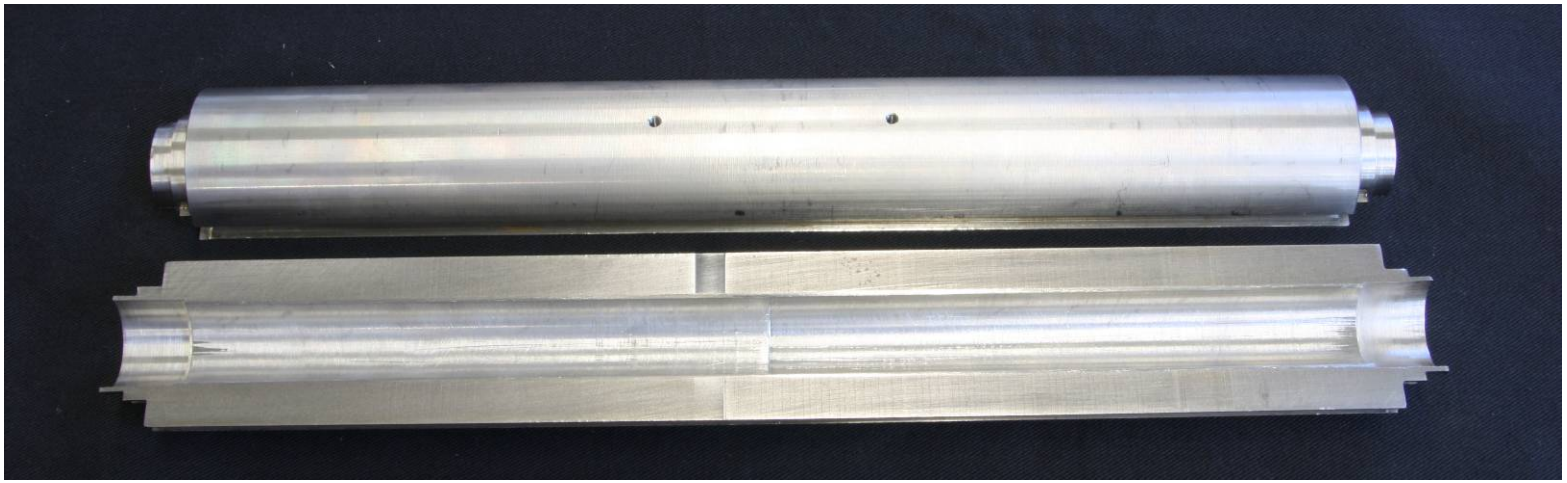
- Experimental setup originally to test current leads.
- Only slight modifications had to be done for the Hot-Spot experiment.
- Quench initiated by heating the He inlet temperature.

Short-Circuit after Jacket Removal

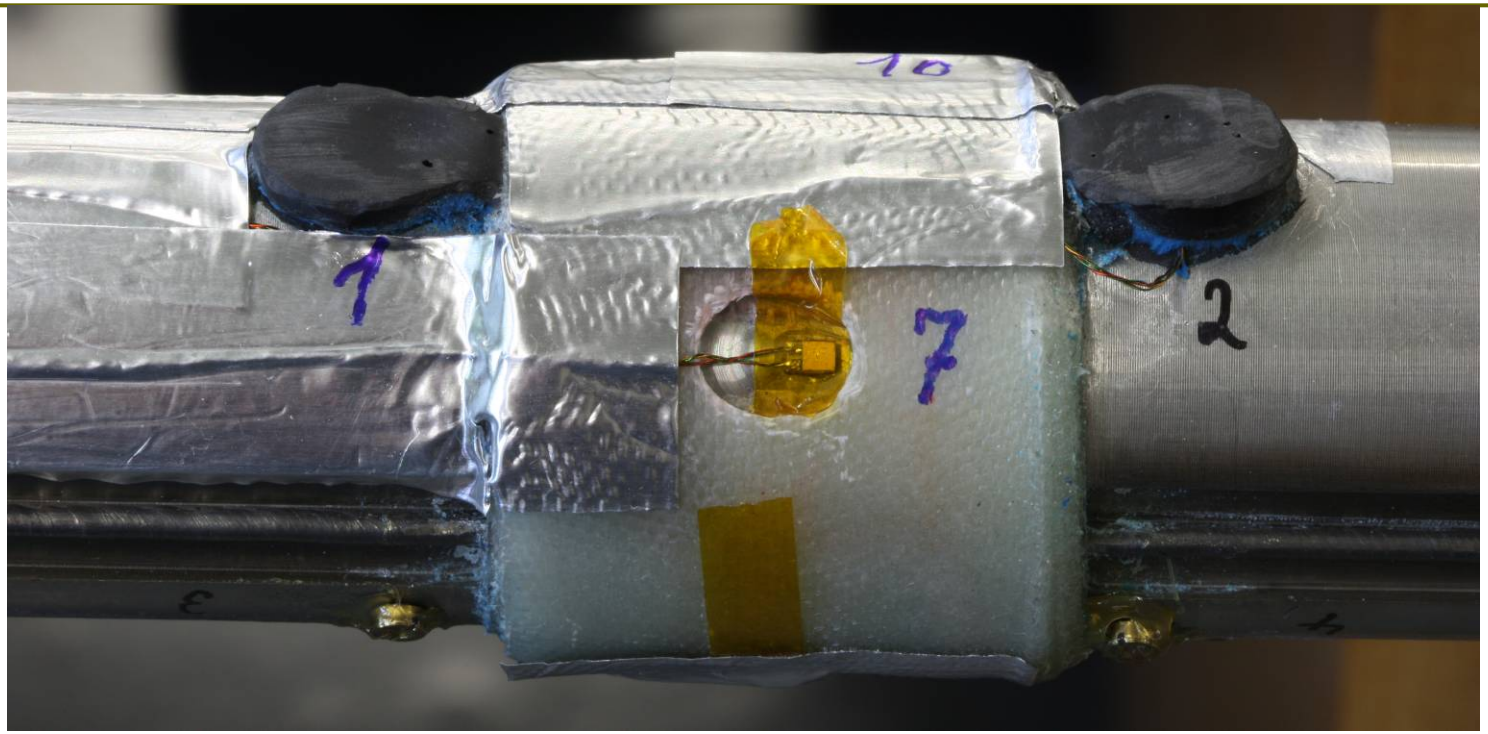
Heating Cable Locally to 400°C

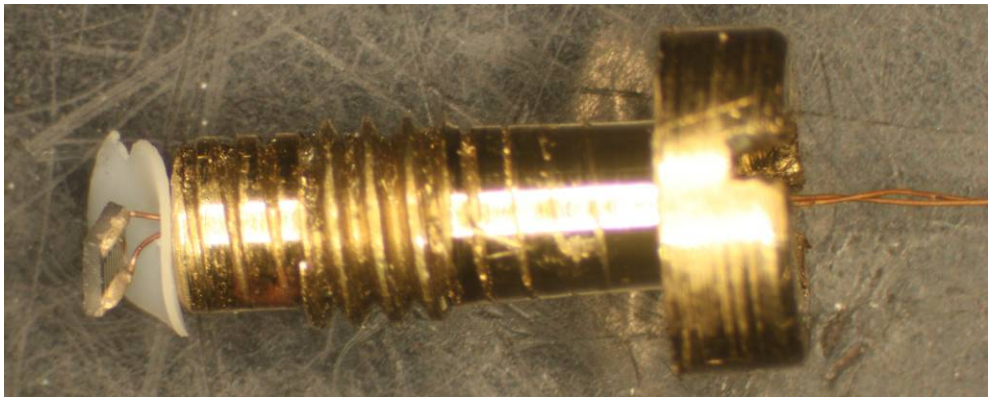


Damaged Cable and Thick Steel Conduit



Temperature Sensors

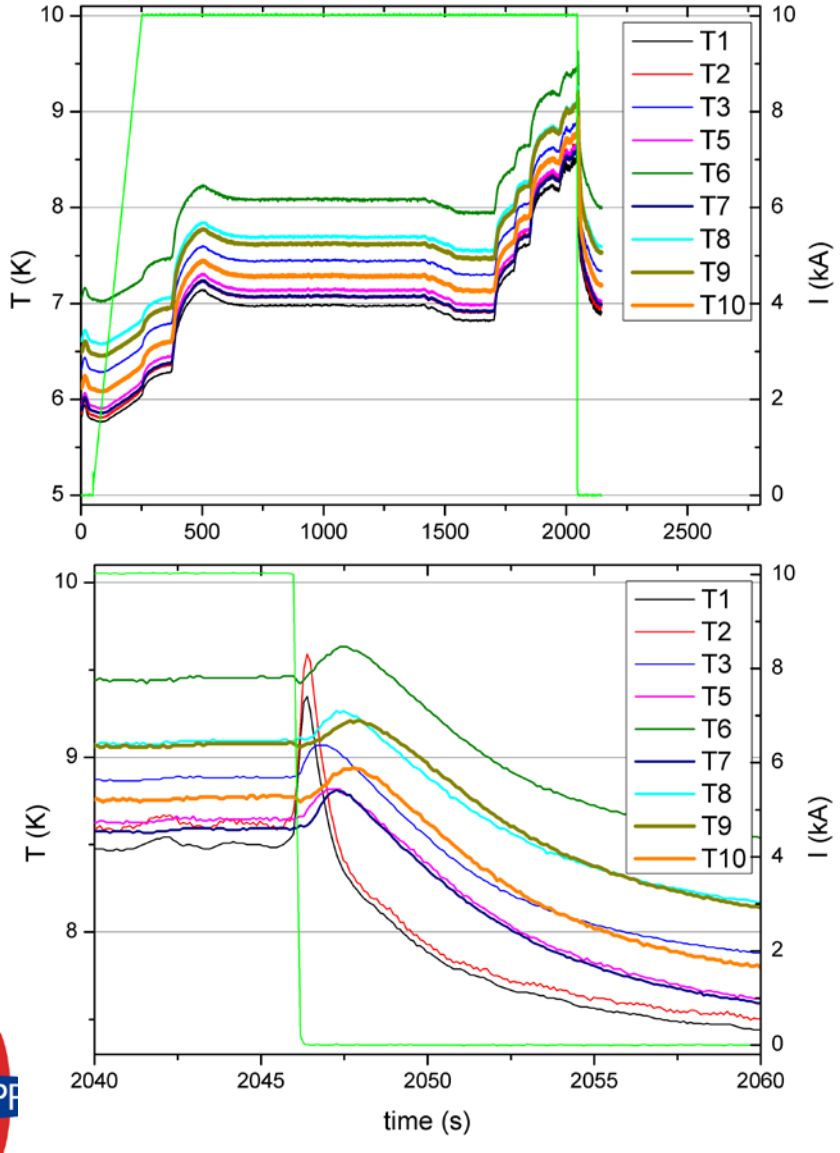




CRPP

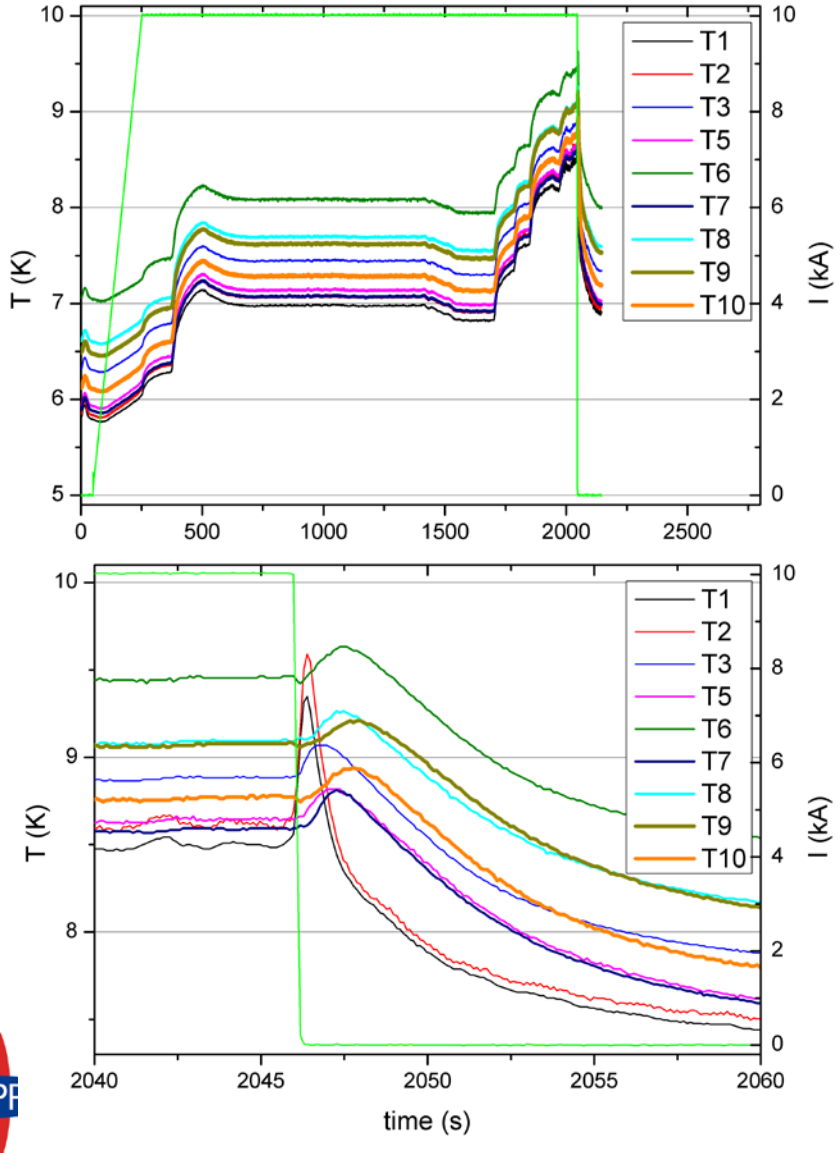
ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

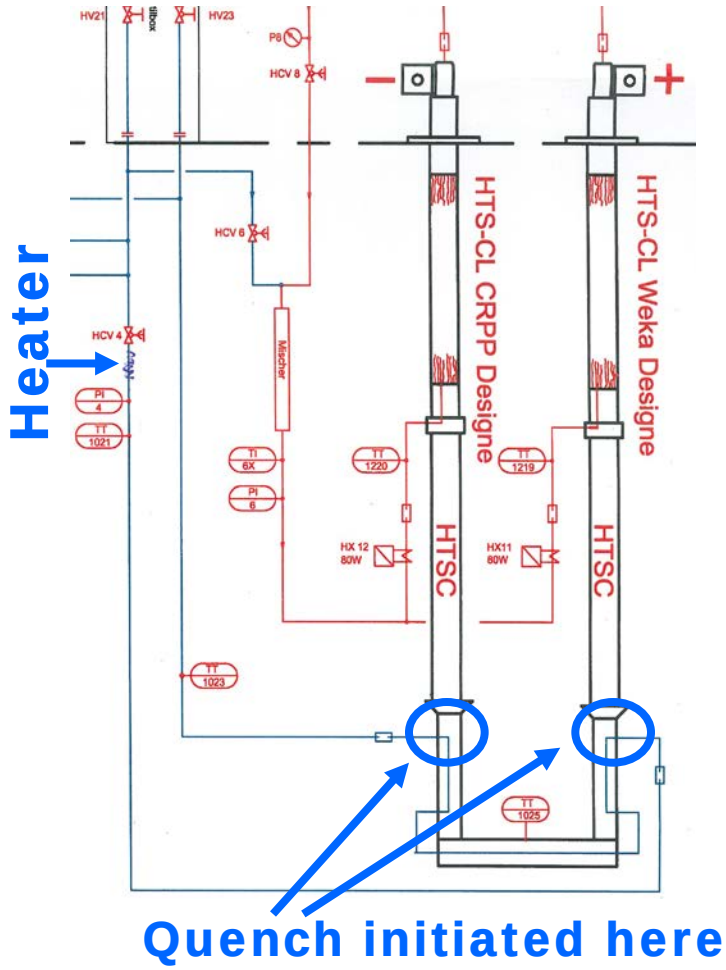
Experiment – First trial



- Temperature rise controlled by a heater located before He inlet.
- Quench initiated not in the required central region, but at the edges (near current lead terminals) ➔  .
- T1, T2 – sensors in He.
- T9, T10 – sensors on the insulation surface.
- (Raw signals, temperature offsets are not corrected.)

Experiment – First trial





ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

CONCLUSIONS - Plans for Improvement

- To avoid quench initialization at the edges, we intend to modify the cooling circuit (to cool down the edges of the short-circuit cable by 4.5 K helium).

and

- Add a small NbTi coil (~1-2 T) around the centre of the short-circuit to initiate the quench in the damaged NbTi region at lower temperature.

➔ REPEAT THE EXPERIMENT