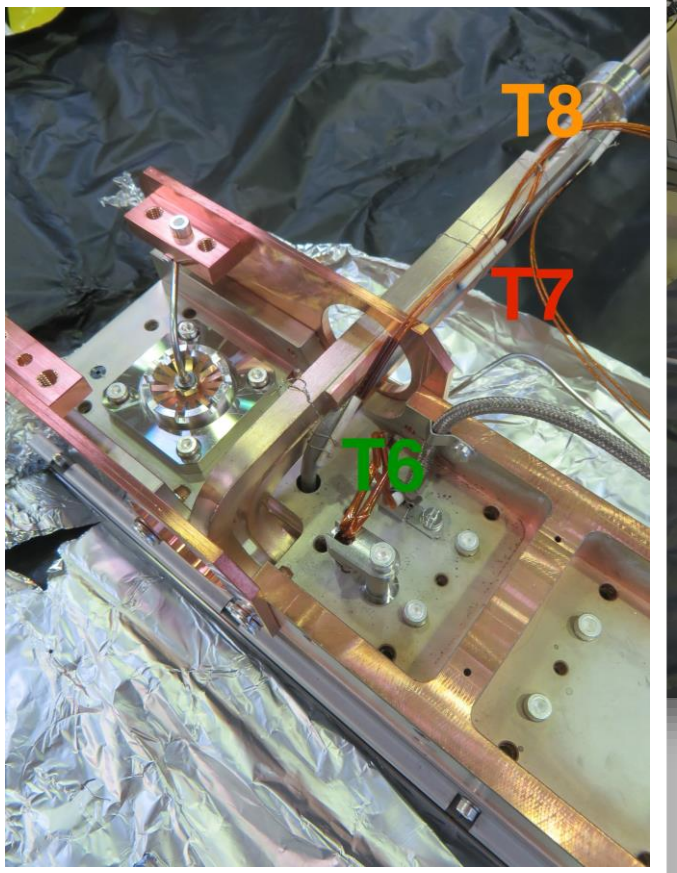
Planned adjustment of the temperature interlock of the BBCW

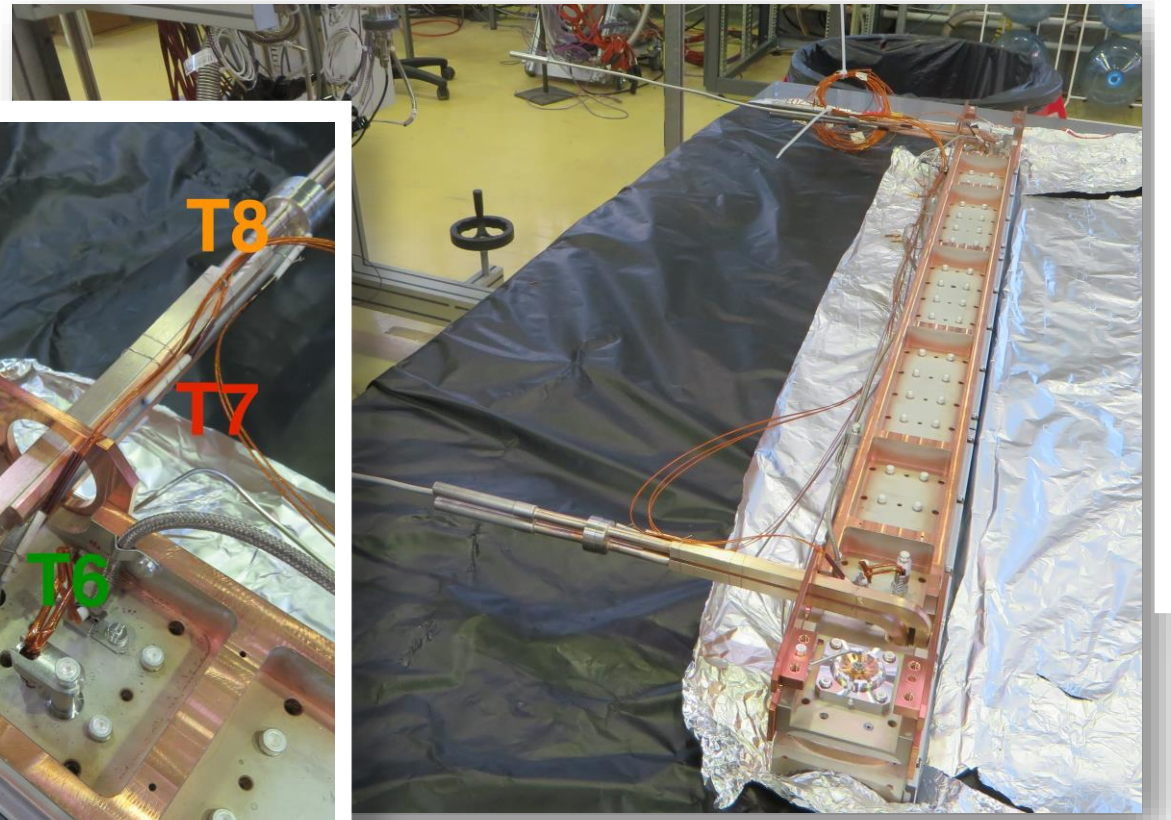
Adriana Rossi @ 253rd MPP meeting – 13 Sept. 2024

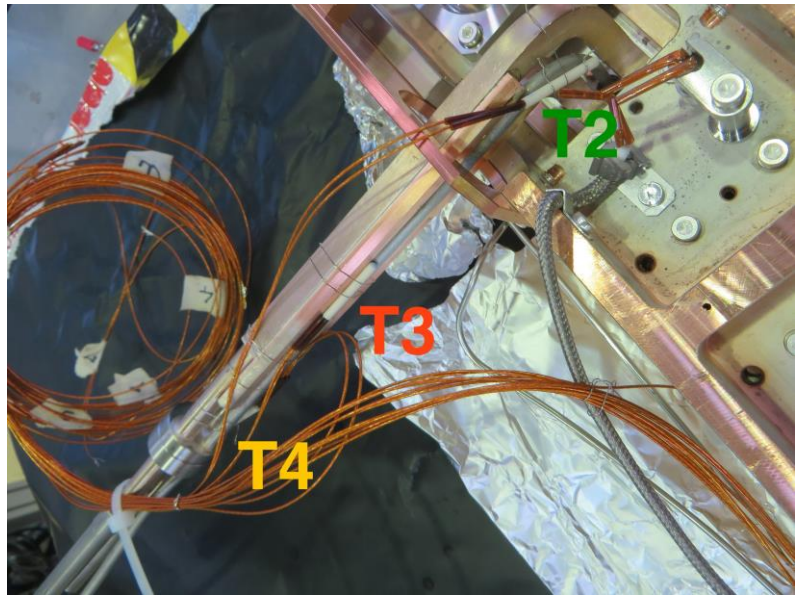
Outline

- Recap on BBCW temperature interlock
- TCTPH.4L5.B1 wire over threshold
- Results from the tests in the machine (TCTPH.4L5.B1 and TCTPH.5R5.B2 for comparison)
- Modification of threshold and interlock validation
- Conclusions

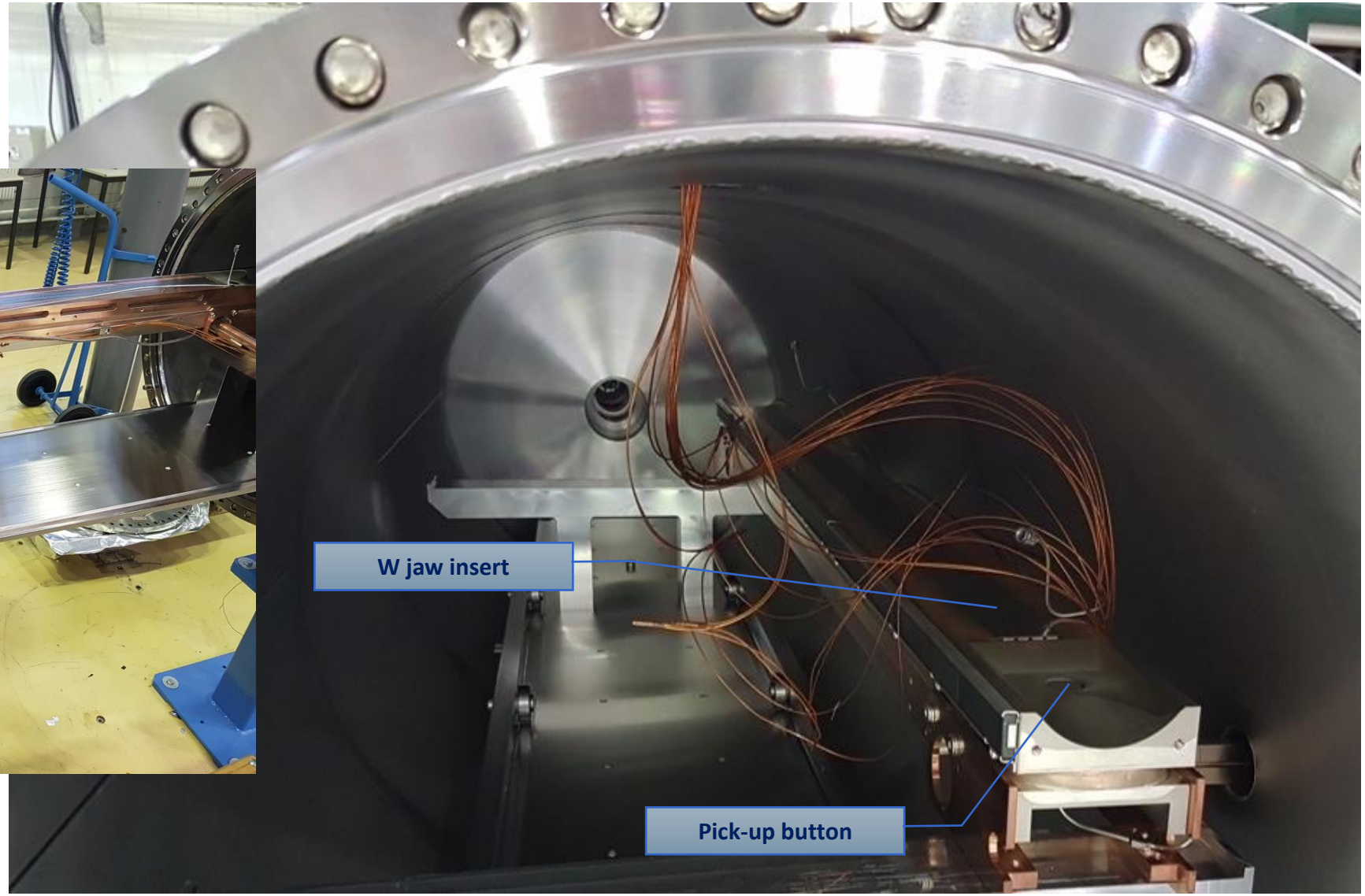
Spare wire-in-jaw equipped with T sensors



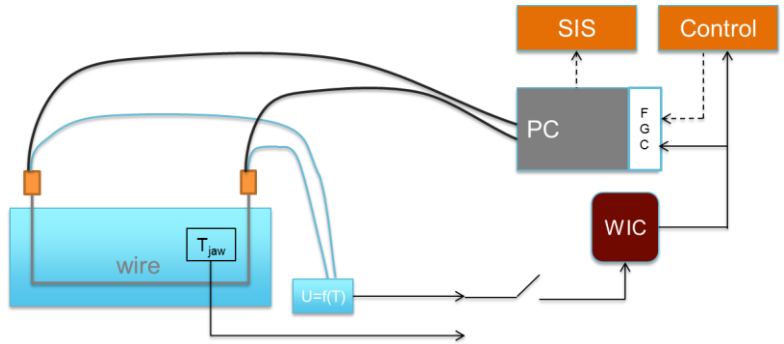


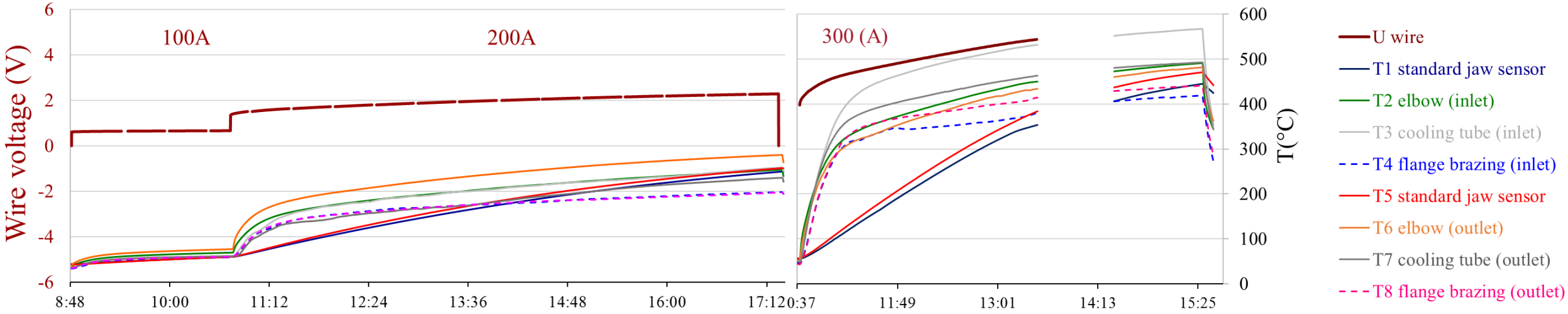


Spare wire-in-jaw equipped with T sensors



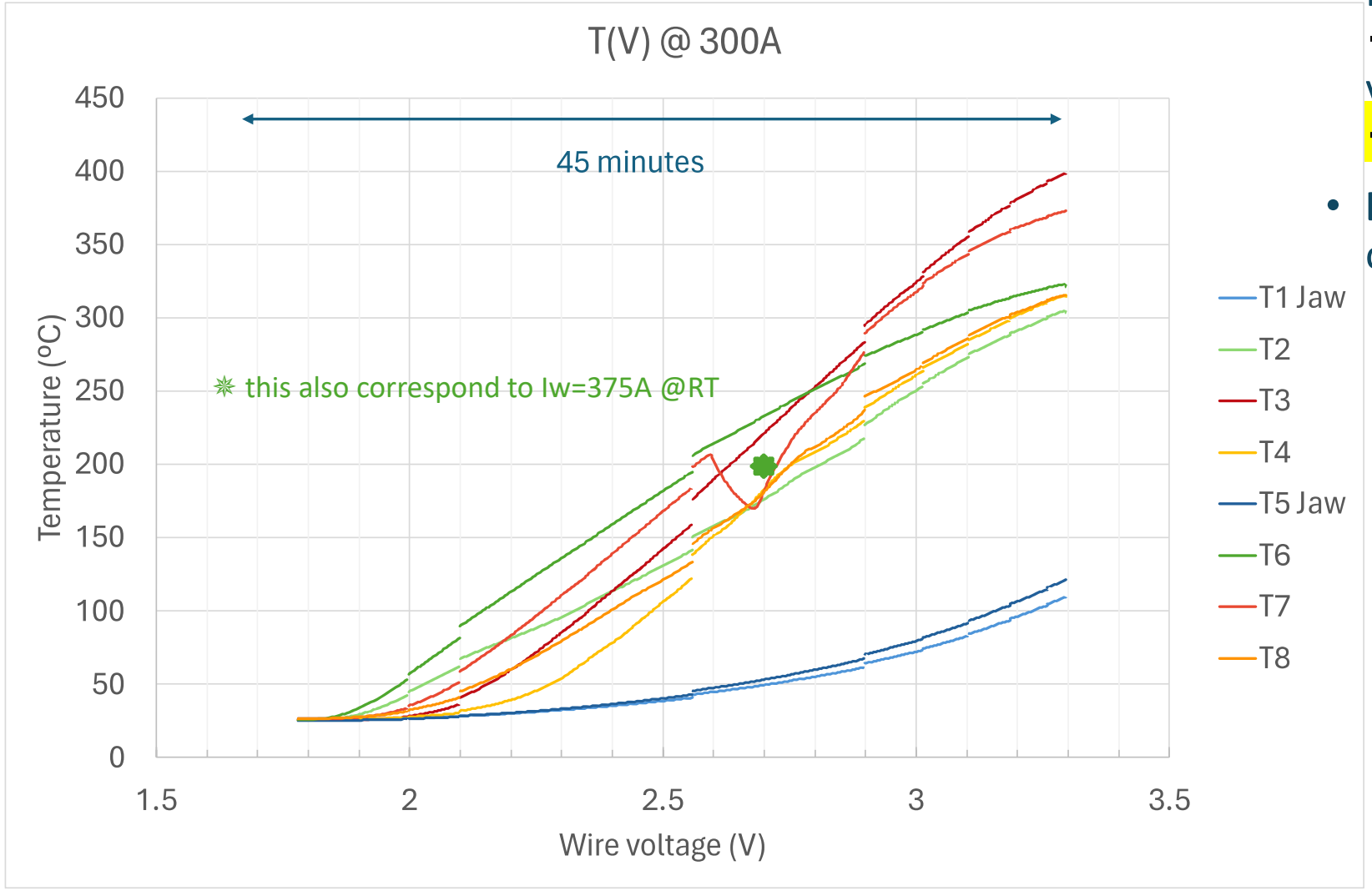
Wire interlock threshold determined with measurements under vacuum / without cooling





Note the time evolution of several minutes

Wire interlock threshold



- Wire resistivity f(T)
- If wire voltage > 2.7V*
  ➔ if hottest point @ 300A inside vacuum ~ 200°C
  ➔ beam dump + WIC cuts the PC
- **Long time constant of system**, no constraints on collimator HW

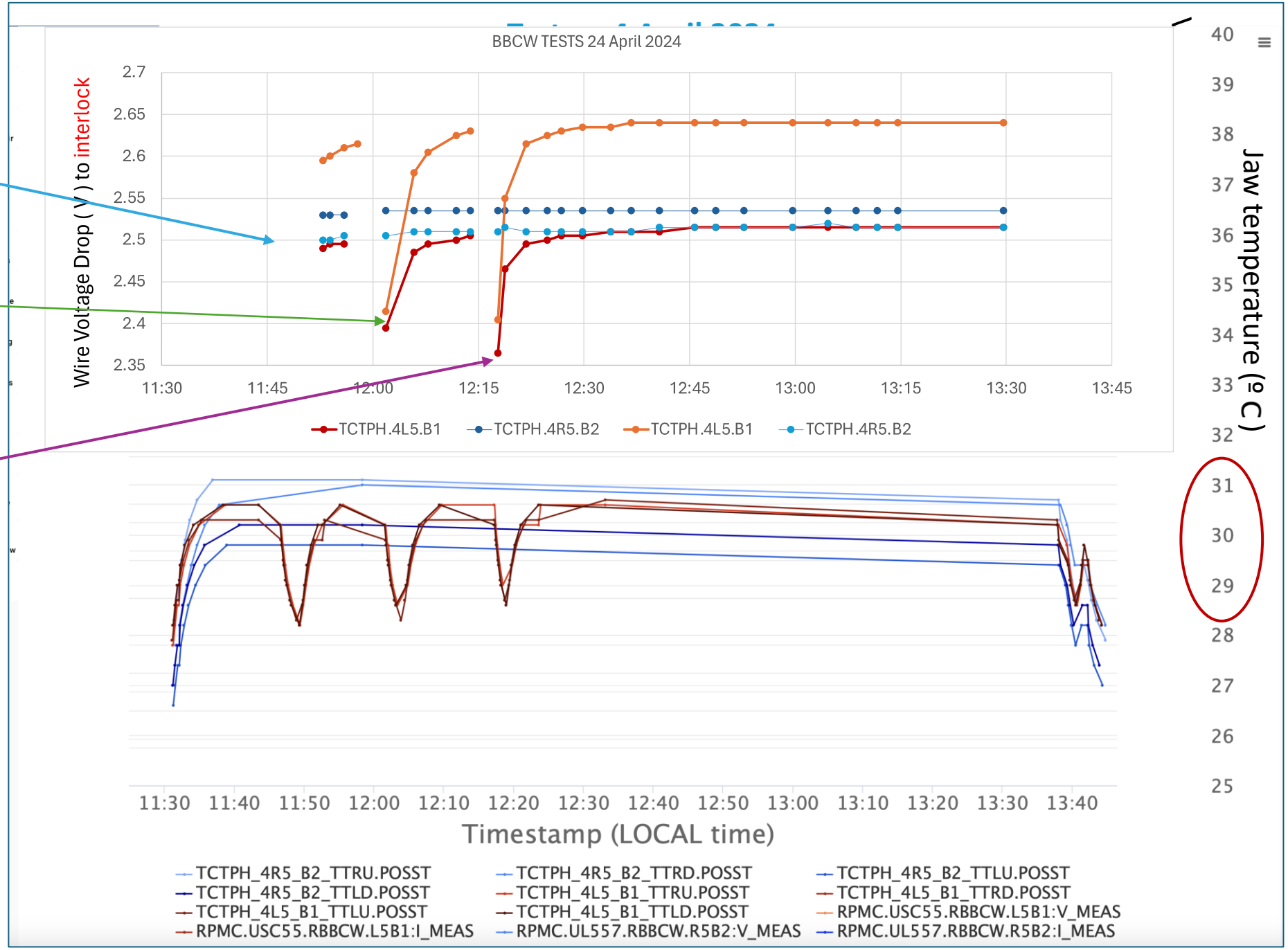
T interlock triggered on TCTPH.4L5.B1 (24 April 2024)

- Interlock tested @ 375A
- Wire temperature measured in situ for 20-25 min @ 350A
- Around Easter, interlock triggered after ~ 40 min @ 350A only on this collimator
- Operation resumed after rMPP @ 315A

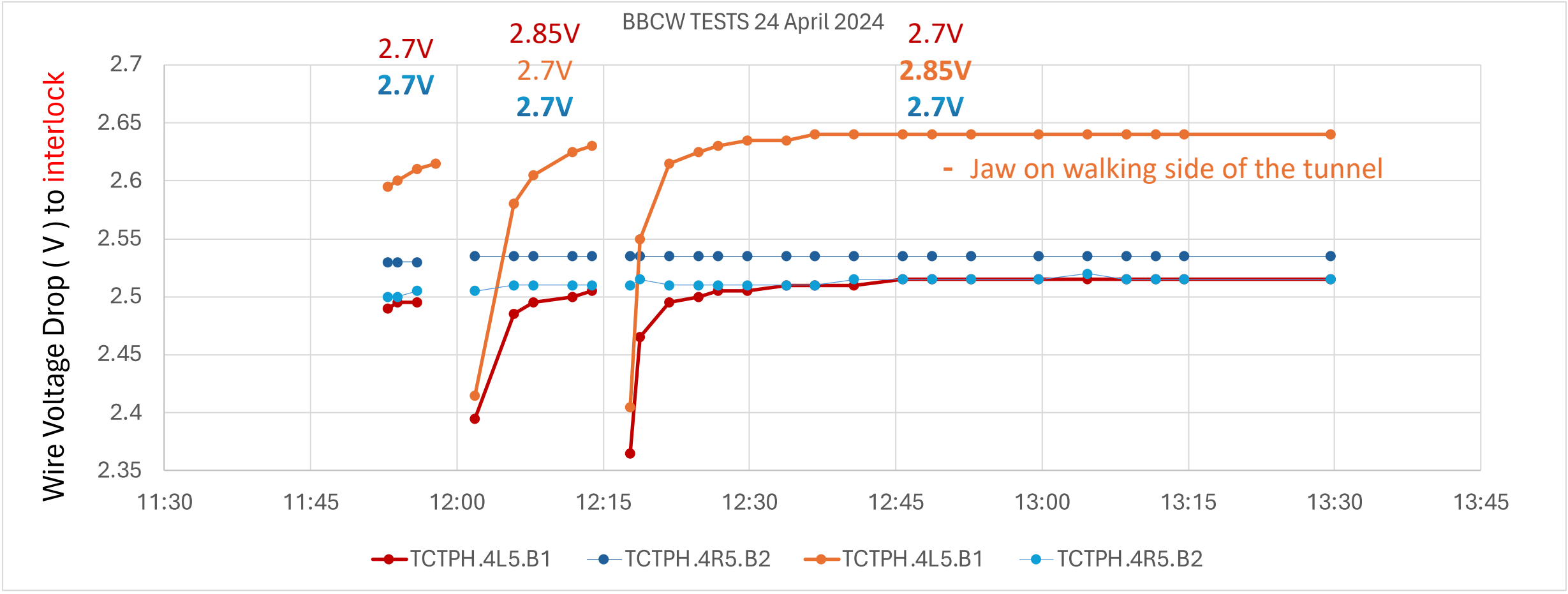
interlock triggered by moving cables

Interlock while modifying the threshold value

Interlock while just touching the voltmeter cable to thd lvl 1-1



Threshold values (each wire has a reading + card)



Conclusions and outlook (May 2024)

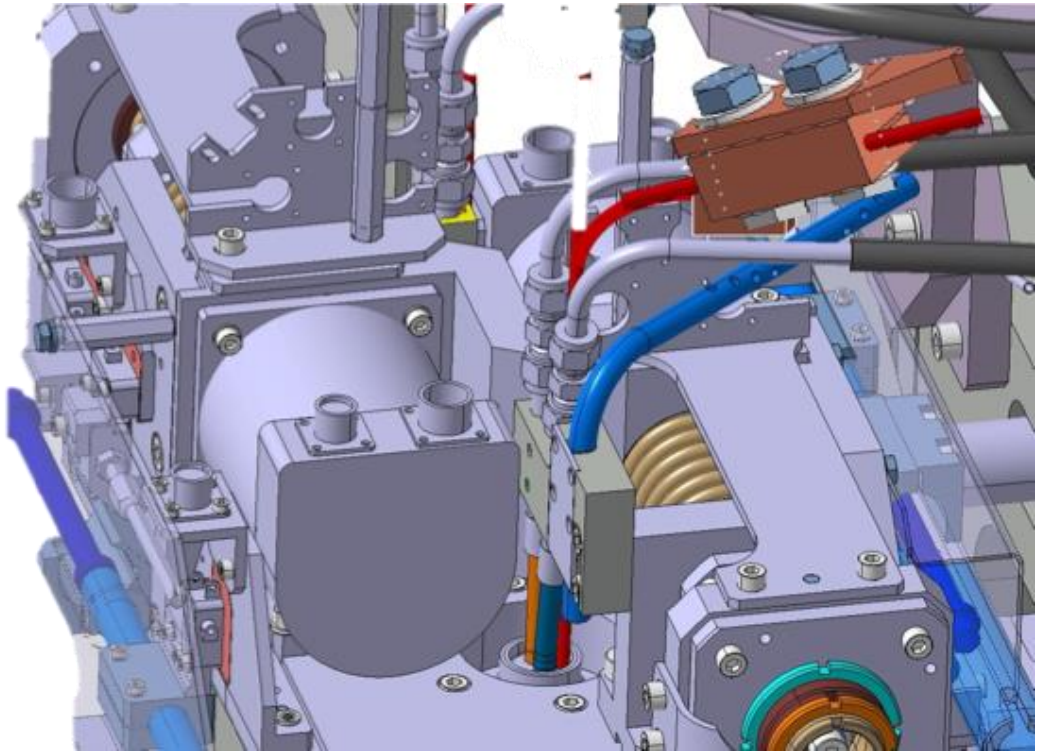
- Tests show that the wire temperature inside the collimator reaches equilibrium around 30ºC, both on TCTPH.4R5.B2 and TCTPH.4L5.B1
- One wire-in-jaw exceeds threshold at 350A
- If rising the threshold (by < 6%), the voltage measured across the wire goes to equilibrium, indicating that there is no temperature run away
- The T externally to that wire was measure > 300ºC: could it be the clamp not tighten as elsewhere?

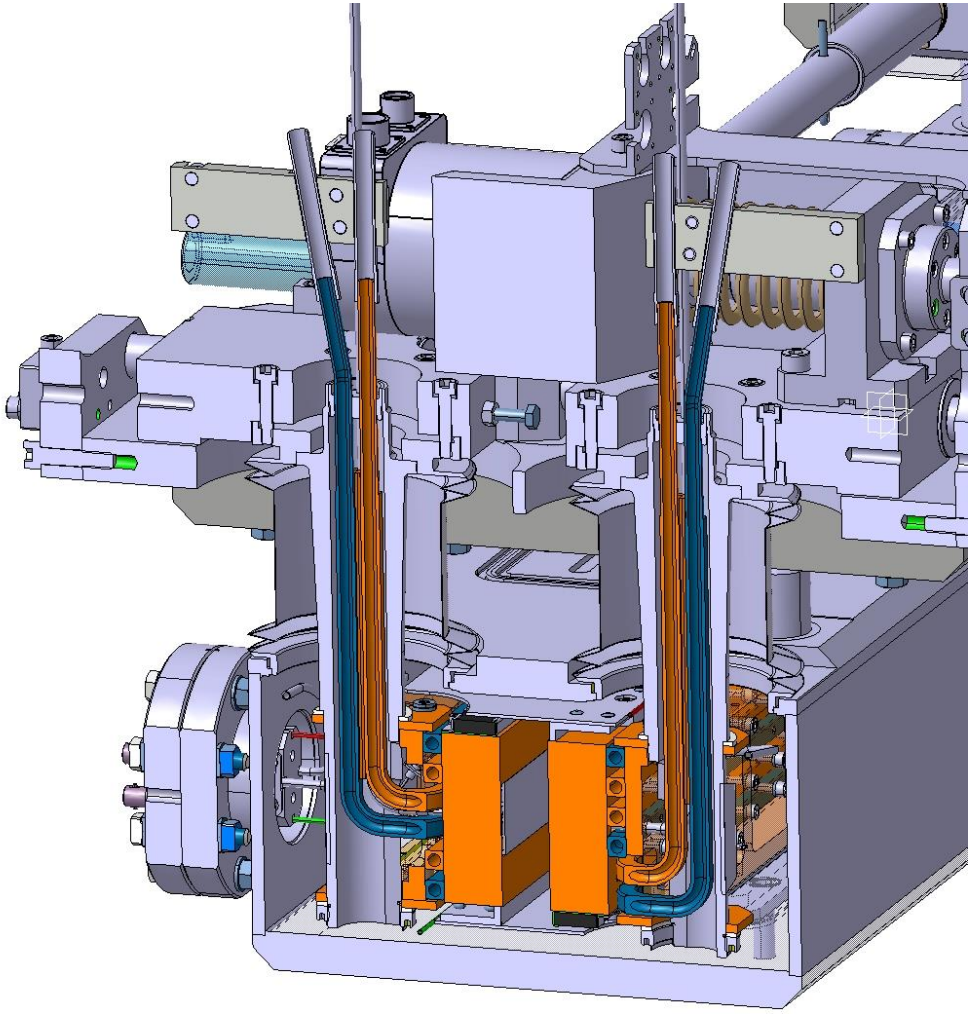
TS1

➔ Tighten the connection suspected to cause the problem

➔Repeat tests @ 350A over 1h or more measuring the temperature outside (still to see how)

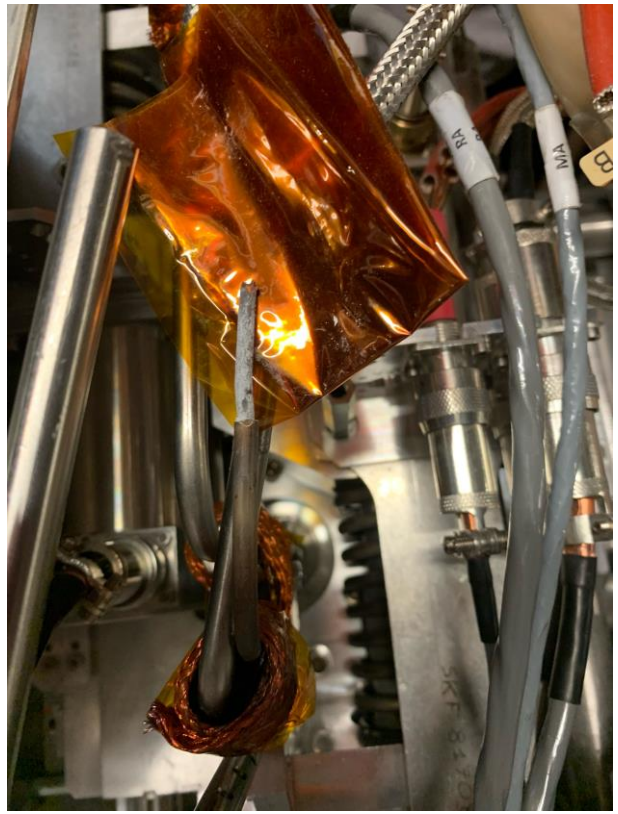
Wire after repair (courtesy of L. Gentini)

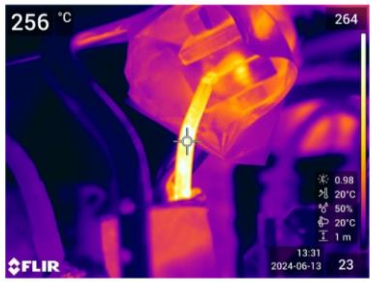


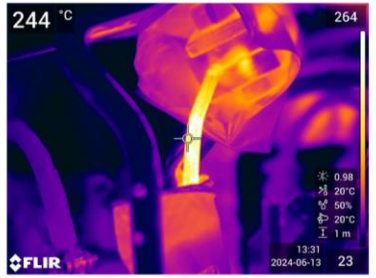


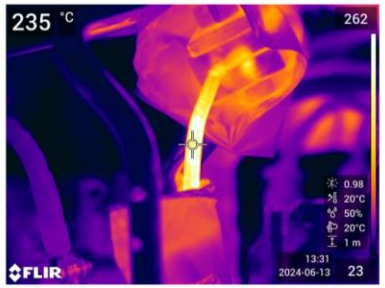
Intervention on 13 June 2024

- We (Wilfried Devauchelle and myself) dismounted the connections to the flexible on both sides:
  a. One side of the wire (corresponding to where the temperature is higher during operation) had a length of contact (length of the copper wire stripped from the sleeve and insulator, and in contact with the copper clamp) about 1/3 shorter than the others. This means that the surface to conduct the 350A was smaller, inducing larger local heat.
  b. The clamps were only half than in other locations (so the wire was squashed between the beak of the flexible cable – StSt – and 1 copper plate. Dispersion of heat was therefore lower.
- Solution: we replaced both sides clamps with double sided and thicker clamps.
- We then run tests at 350A, measuring the voltage drop on both wires (one per collimator jaw).
  a) The voltage stabilized after about 40 to 45 min, with values comparable (for both wires) to what was measured during tests on Apr 24.
  b) The test could run for 1h45 min without triggering the interlock. (see picture annexed)
  c) The temperature of the wire (measured with a thermal camera) close to the clamp was ~260ºC (highest 256C, lowest 235ºC) (see pictures annexed)
  d) The temperature close to the 'bague' where the wire is brazed, to go from vacuum to air, was ~ 70ºC, and the bague itself cold. The temperature of the piece holding both the wire and the cooling tubes to the support in the same range.
- We repeated the test at 350A today for more than 3h and did not trigger the interlock. We tested the interlock, and it was ok.

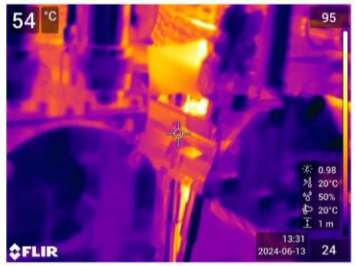


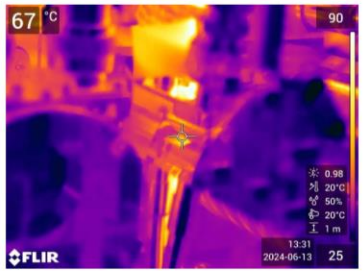




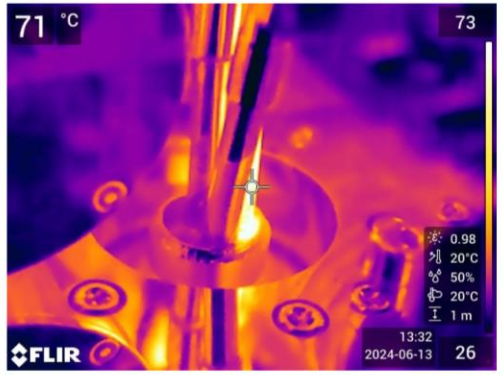


3) temperature measurements of the hottest part of the wire



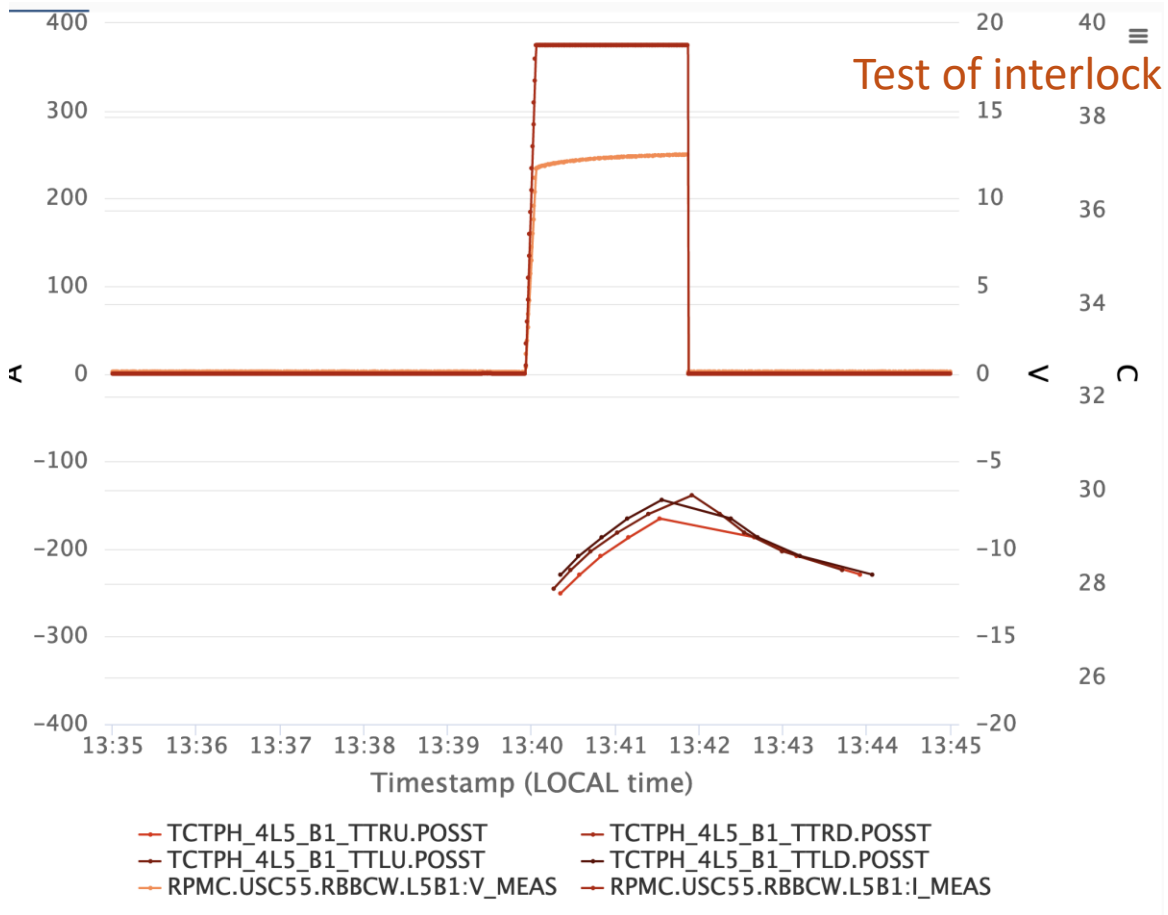


4) temperature measurements of the wire+cooling tube holder

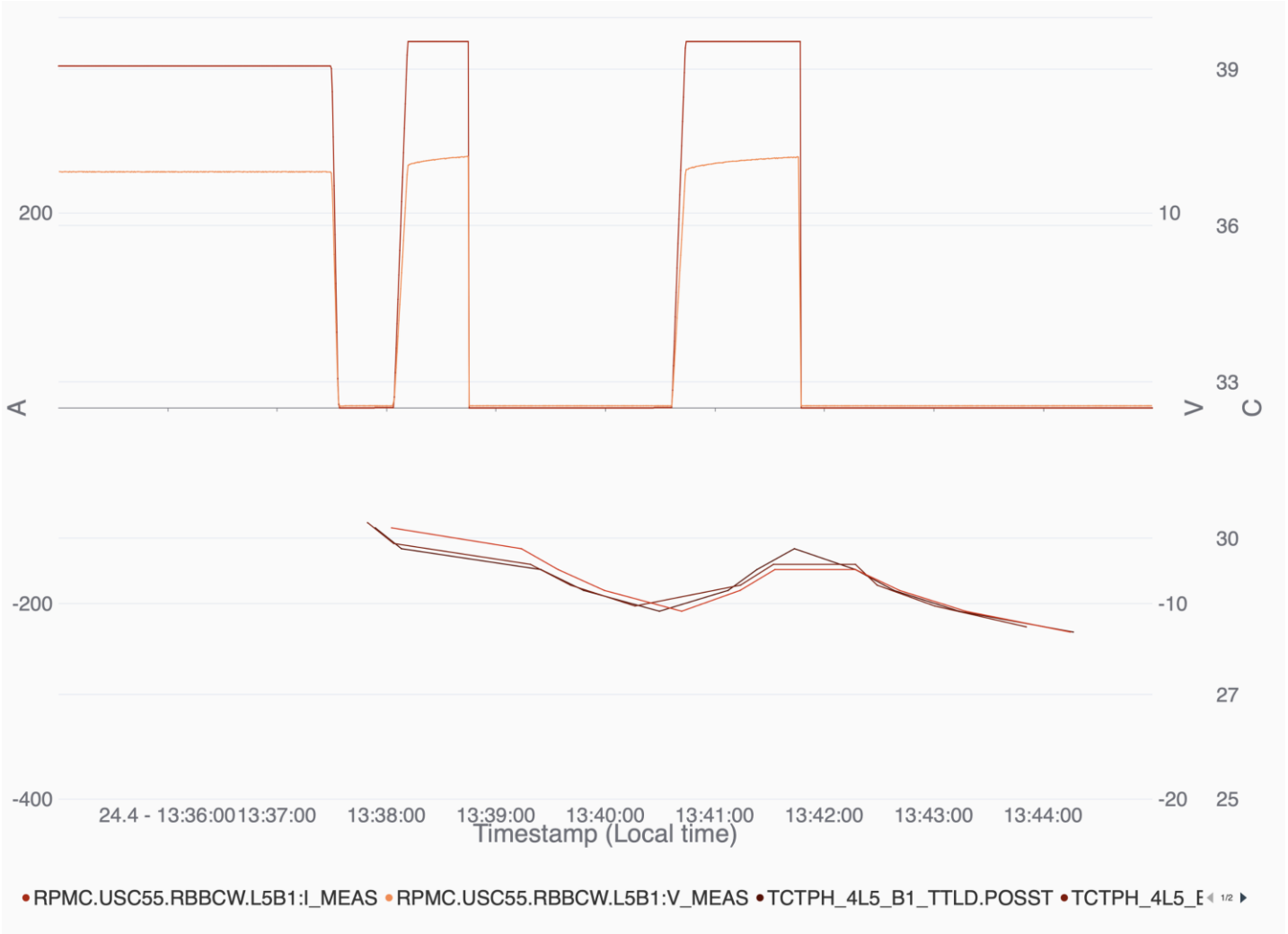


4) temperature measurement of “bague” cooling tubes and wire

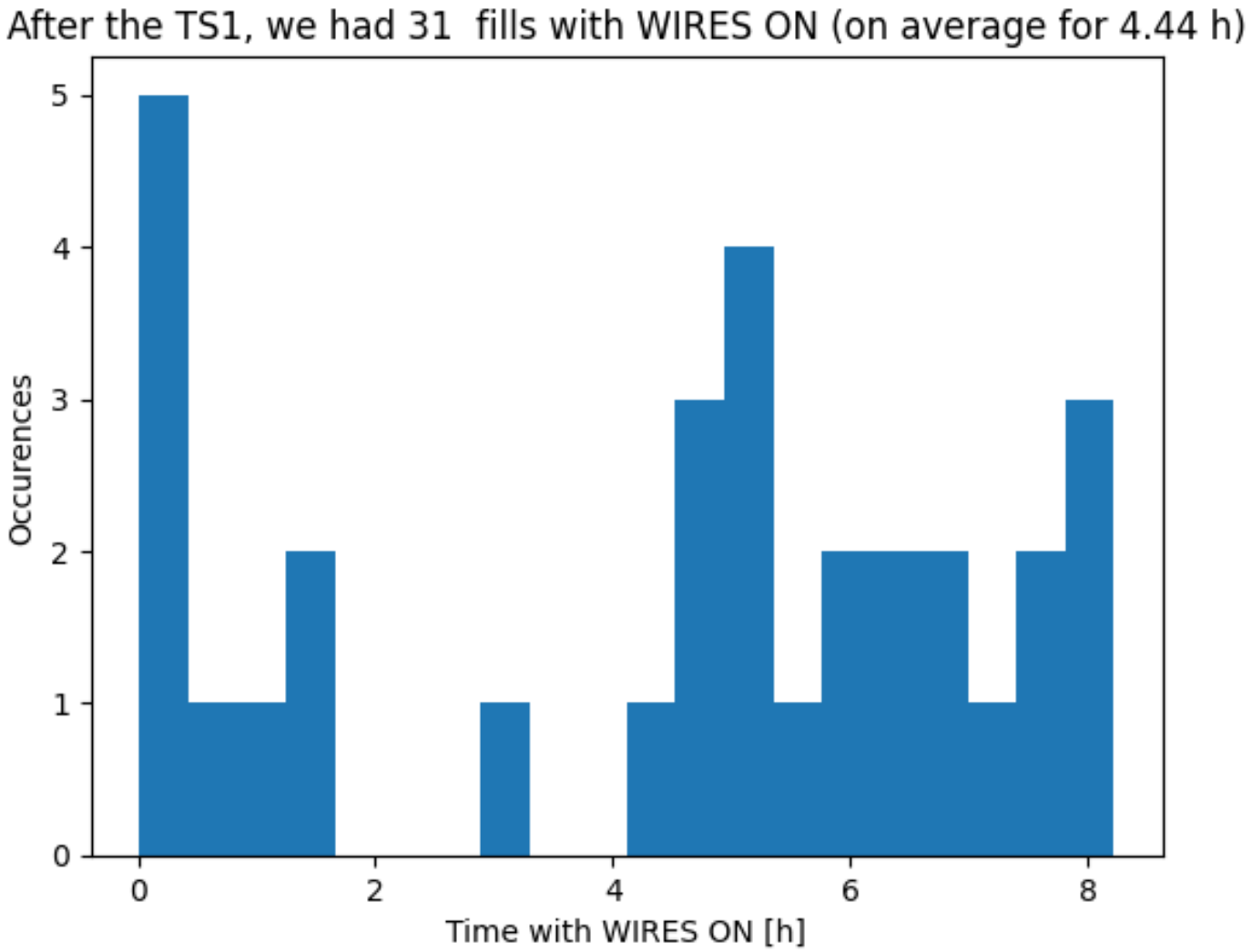
Change of V threshold on TCTPH.4L5.B1 (only on wire concerned) from 2.7 to 2.8V (26 June 2024)



Interlock check TCTPH.4L5.B1 (same wire) @ V_{th}=2.7 V (24 April 2024)



After fix and threshold rise

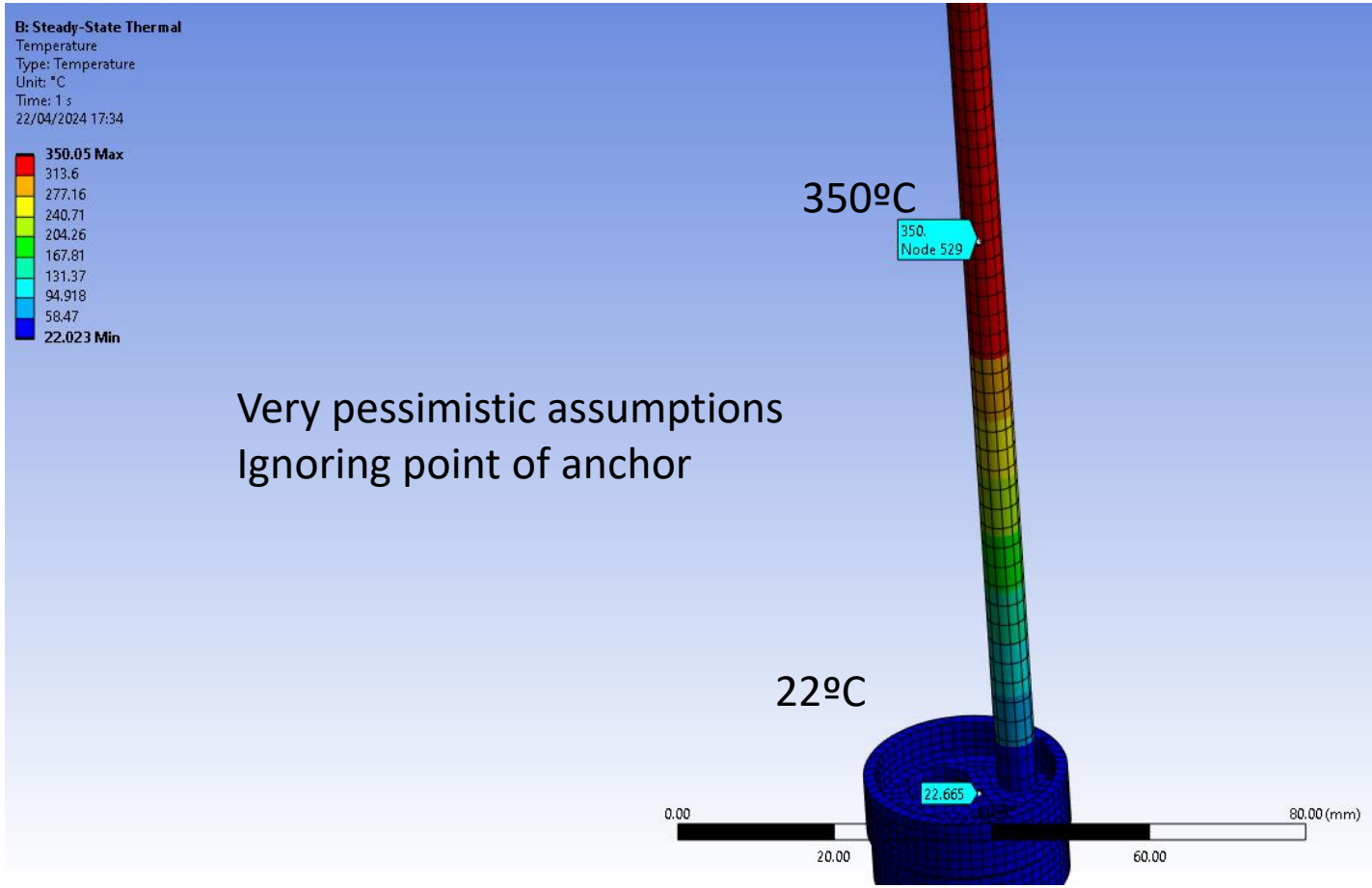


Courtesy of Guido Sterbini

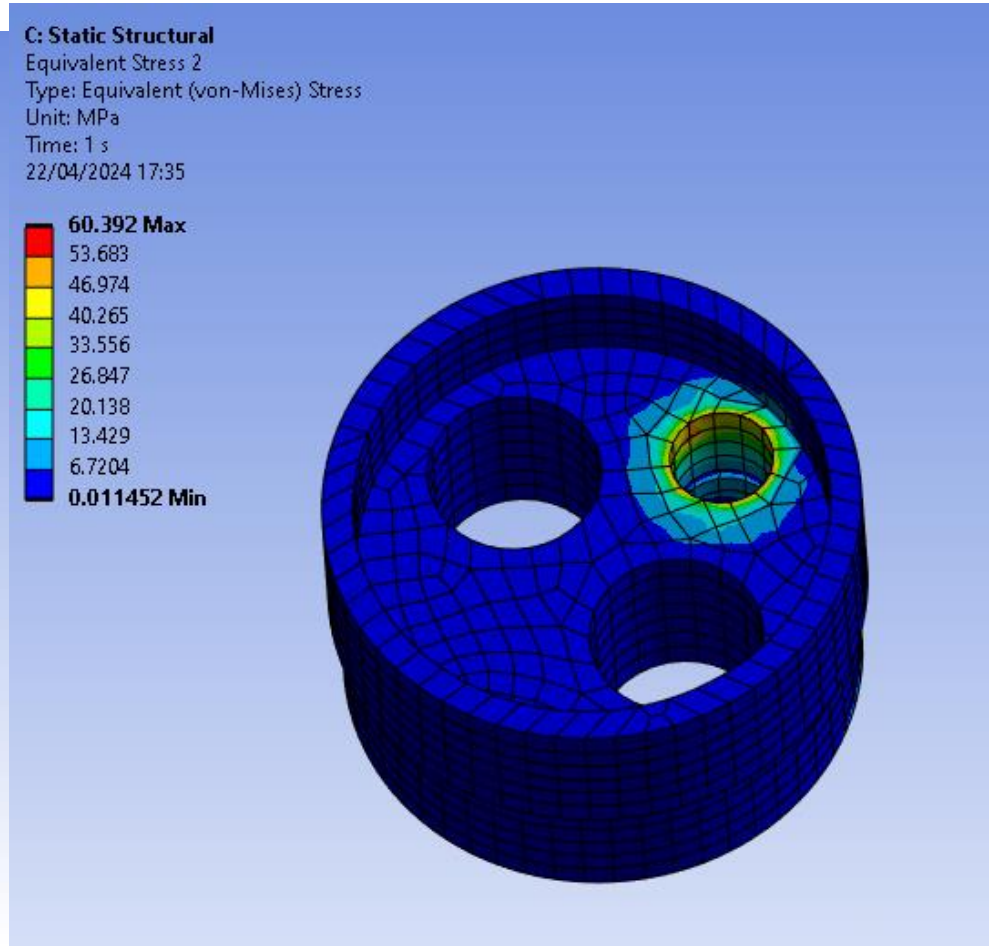
Summary

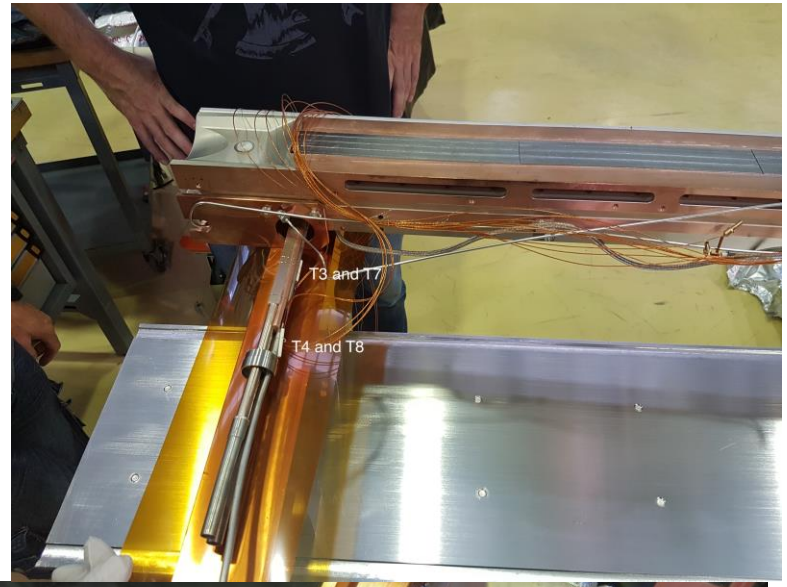
- The threshold voltage on the wire (jaw on tunnel passage side) of the TCTPH.4L5.B1 has been modified from **2.7V to 2.8V**.
- This rise is to compensate for the local overheating of the wire extremities that are shorter (about 2 instead of 3 cm).
- The new threshold was tested with standard procedure.
- Wires have been since regularly powered @350A with no problems observed

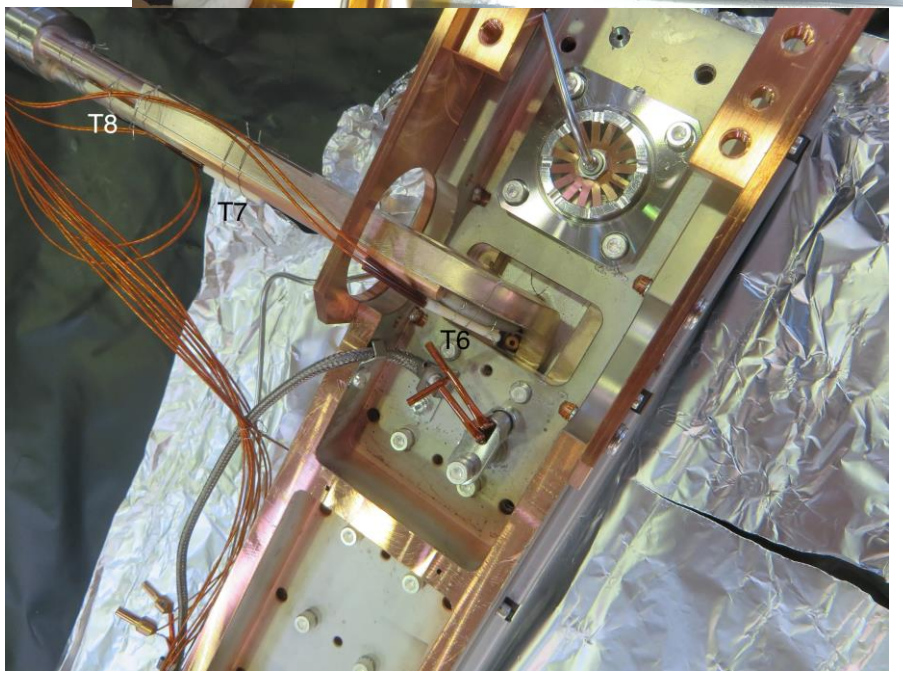
T simulations (courtesy of F. Carra)

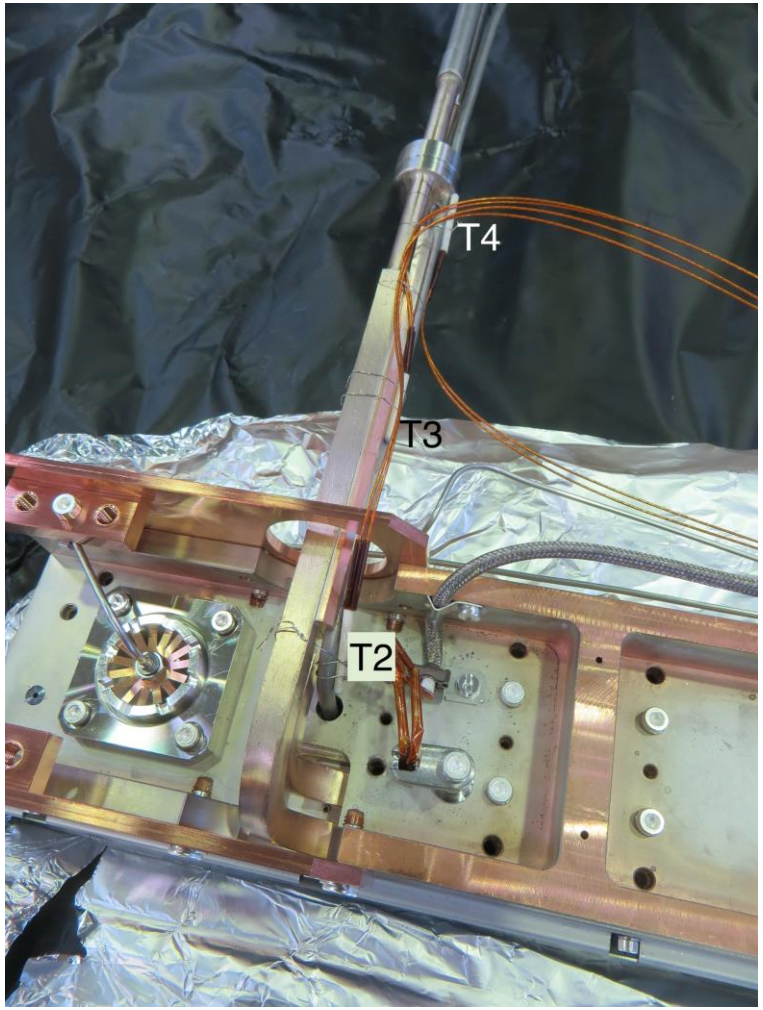


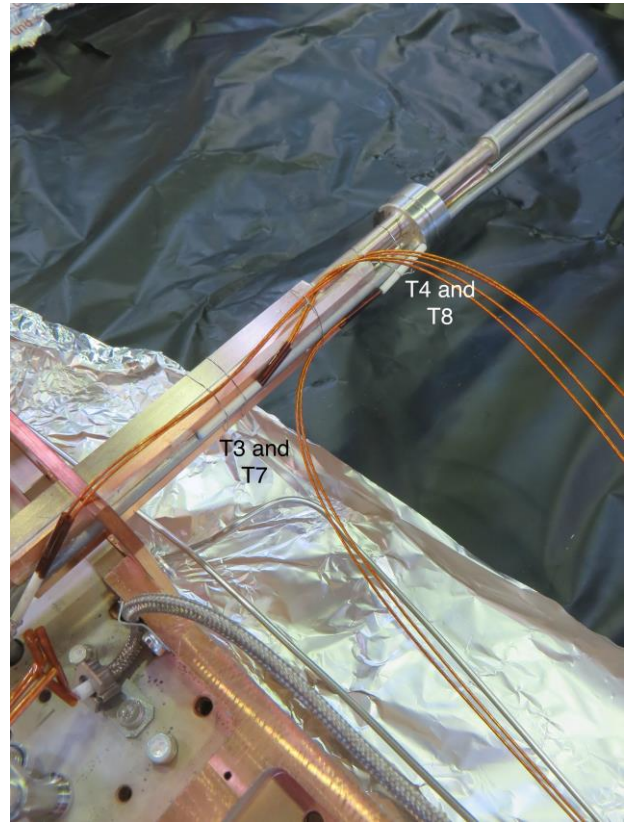
Very pessimistic assumptions
Ignoring point of anchor




T3 and T7
T4 and T8


T8
T7
T6

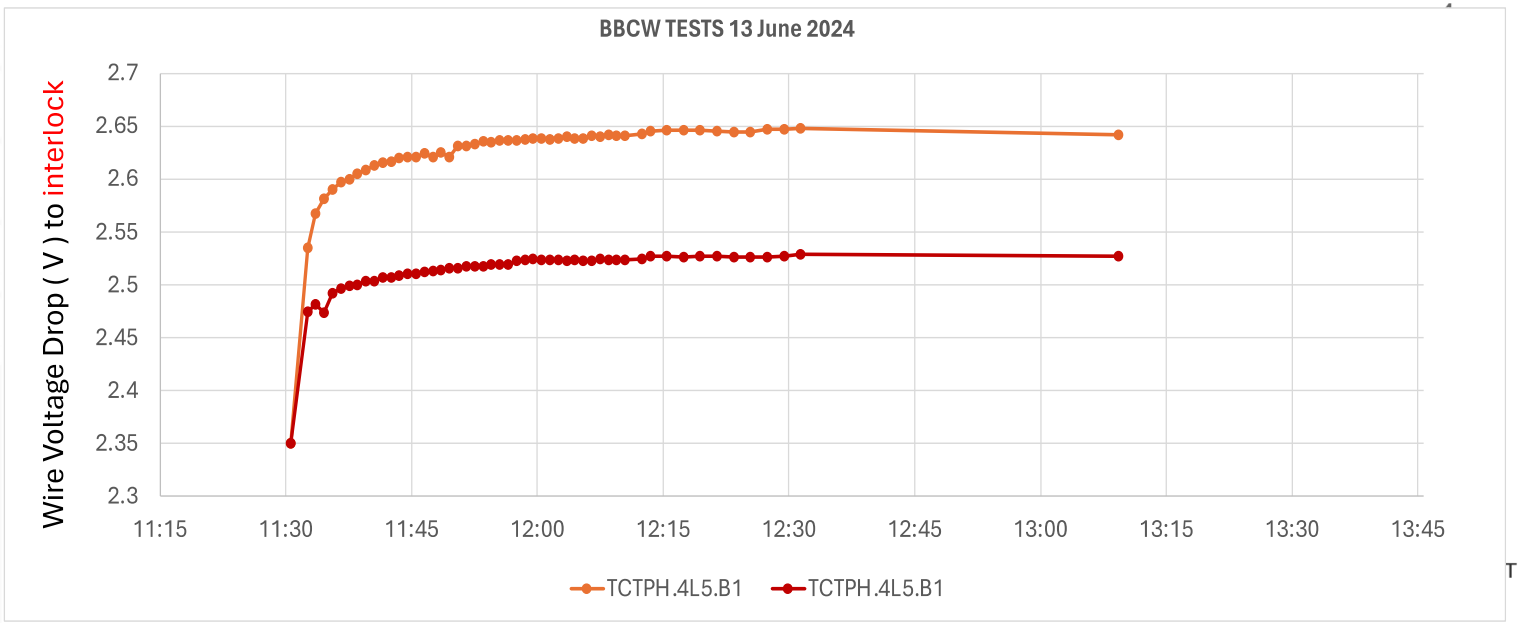

T4
T3
T2

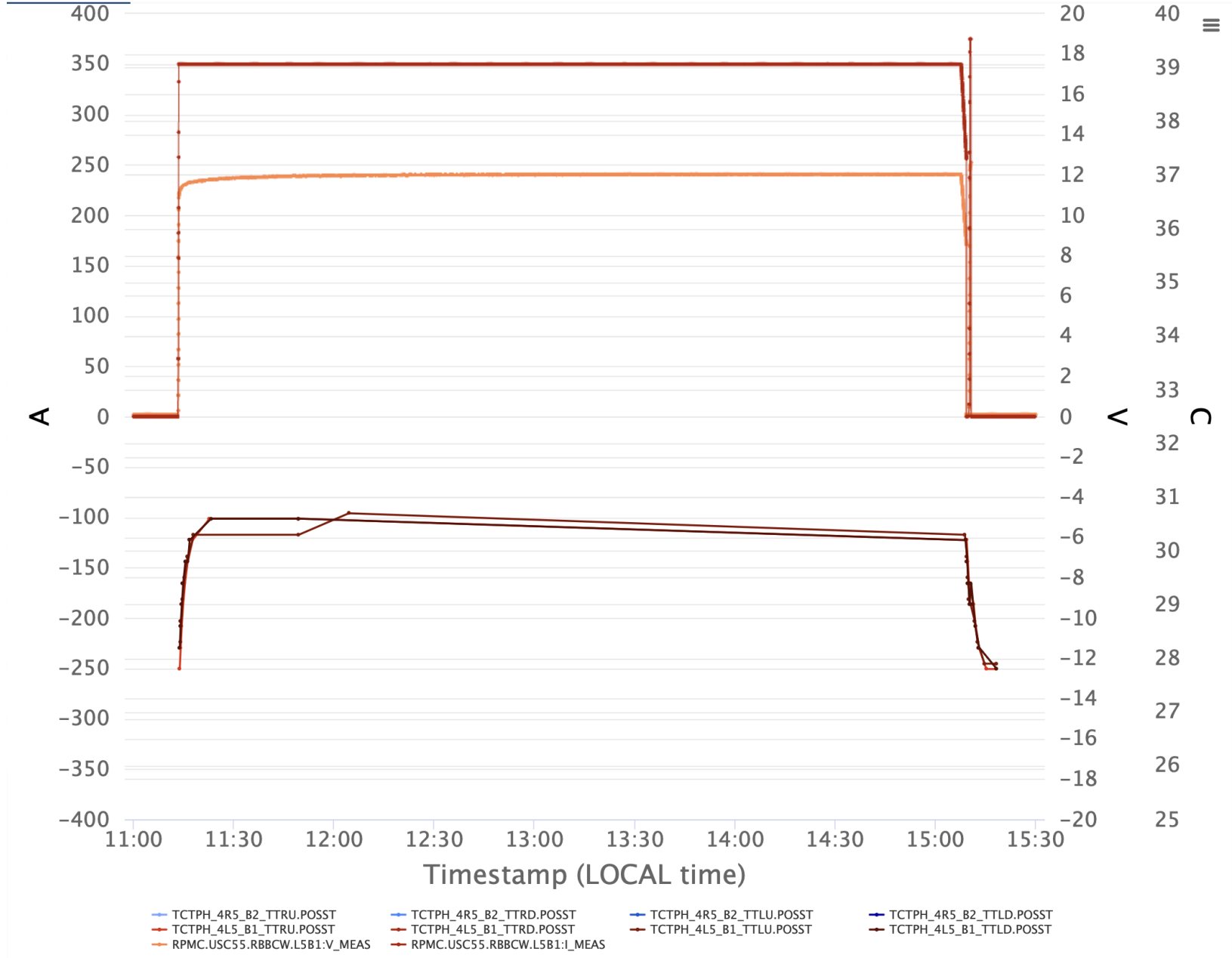

T4 and
T8
T3 and
T7


LVB


BBCWE.R5
BBCWI.R5
BBCWE.L5
BBCWI.L5
LOG STS
R1 R2
TCTPH.4R5 RYME01 UL557
TCL.4L5 RYME01 USC55
BBCW Voltage Acquisition and Interlock in IP5
FLUKE
-5.400
Mark McLean
VERO power


A
V
C


BBCW TESTS 13 June 2024
Wire Voltage Drop (V) to interlock
11:15
11:30
11:45
12:00
12:15
12:30
12:45
13:00
13:15
13:30
13:45
TCTPH.4L5.B1
TCTPH.4L5.B1


A
V
C
Timestamp (LOCAL time)
11:00
11:30
12:00
12:30
13:00
13:30
14:00
14:30
15:00
15:30
TCTPH_4R5_B2_TTRU.POSST
TCTPH_4L5_B1_TTRU.POSST
RPMC.USC55.RBBCW.L5B1:V_MEAS
TCTPH_4R5_B2_TTRD.POSST
TCTPH_4L5_B1_TTRD.POSST
RPMC.USC55.RBBCW.L5B1:I_MEAS
TCTPH_4R5_B2_TTLU.POSST
TCTPH_4L5_B1_TTLU.POSST
TCTPH_4R5_B2_TTLD.POSST
TCTPH_4L5_B1_TTLD.POSST