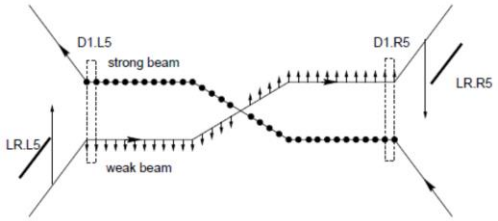


Beam-beam wire collimators (TCTW): new interlocking electronics and proposed commissioning tests for existing and newly installed TCTW

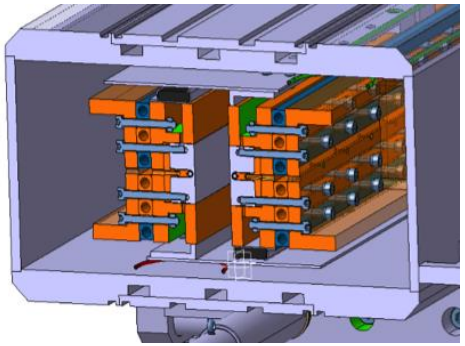
A.Rossi, A.Frassier, W.Devauchelle BE-BI,
L.Ceccone TE-EPC, R.Mompo TE-MPE,
B.Schafer, M.di Castro, A.Grima, R.Fiastre EN-STI
…..

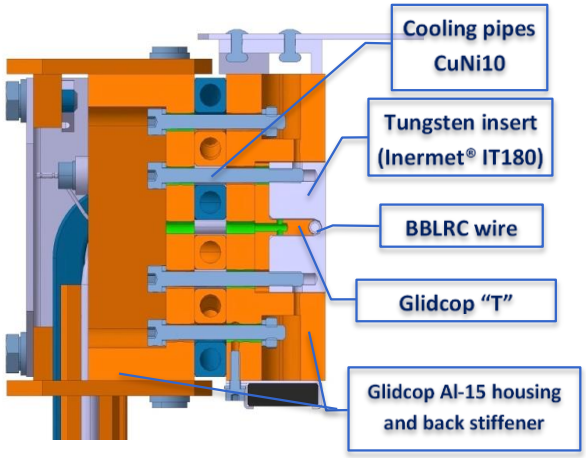
160th SPS and LHC Machine Protection Panel Meeting, 16th March 2018

Outline

- Brief description of wire collimators and logic of interlock
- TCTW wire-in-jaw collimator installation in IR1 and IR5
- Electric scheme and interlock logic
- Summary of commissioning
- Conclusions

Recall of design of wire in-jaw collimator





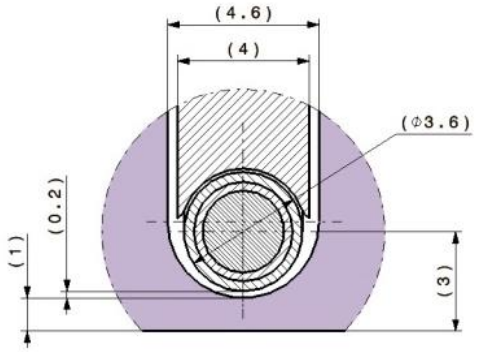
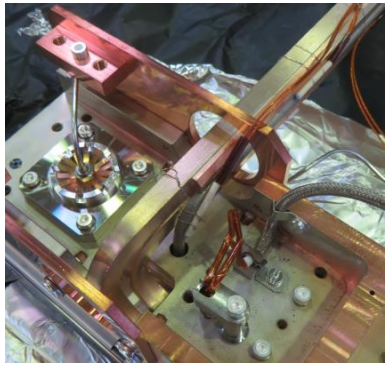
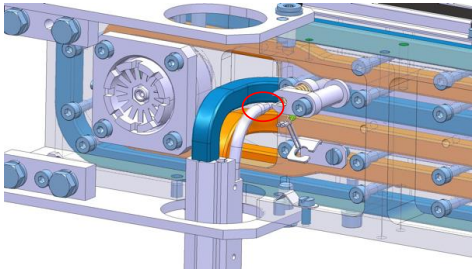


Figure 1 - Details of the wire-in-jaw (left h.s.) and wire dimensions (in mm, right h.s.)





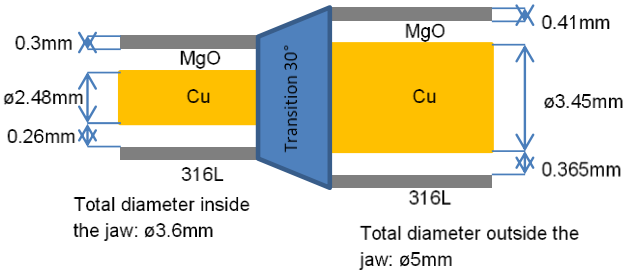


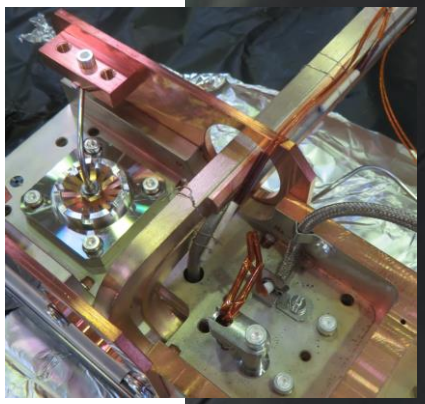
Figure 2 - Jaw cooling and exit of the wire from the jaw where the wire cross section is increased (L. Gentini)

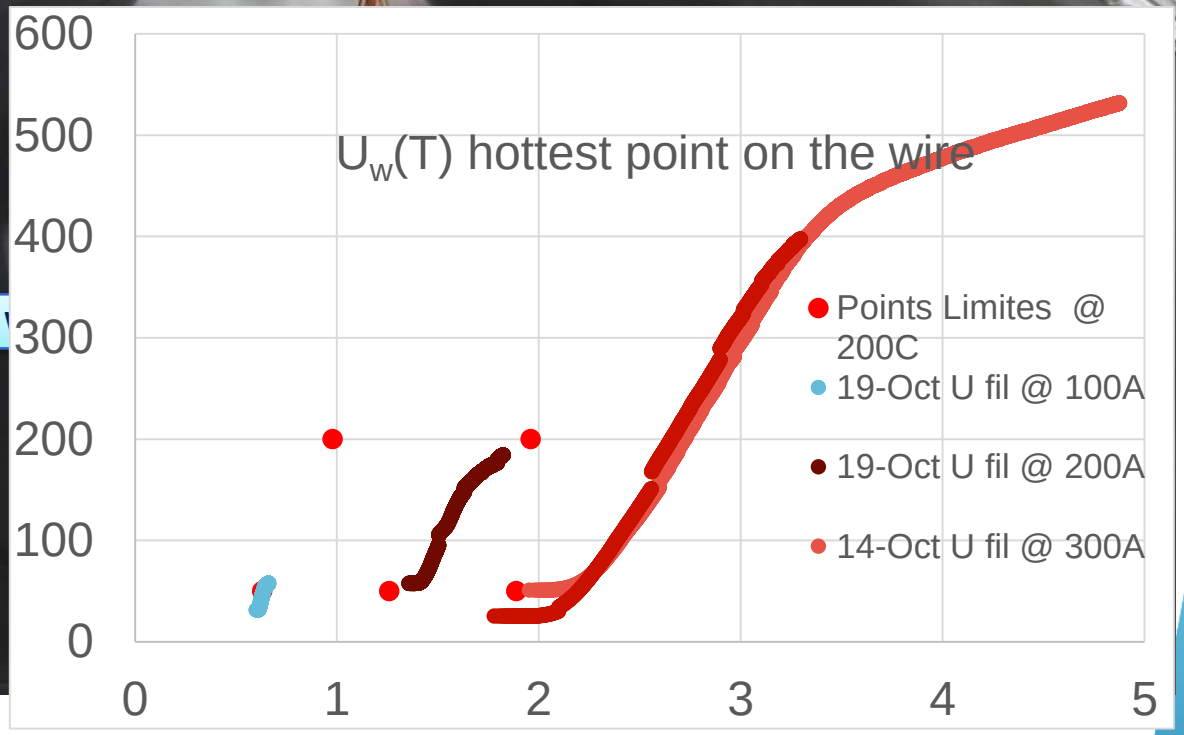
In-jaw wire collimators operations

- Collimator with wire in-jaw installation and ops:
  - 1 wire @ about ±150m from IP1&5 in crossing plane
    - incoming beam TCTPH.4R5.B2 and TCTPV.4R1.B2
    - outgoing beam TCL.4L5.B2 and TCLVW.A5L1.B2
  - Max current ± 350A (cooled)
  - Wire moving in plane of beam crossing
    - 5 µm measured reproducible accuracy of jaw position
    - < 200µrad tilt
  - Possibility to move the wire in transverse plane (collimator 5th axis) to align to orbit
    - ~ 100µm from BPM (to be confirmed with measurements)
- Interlock to protect overheating in case of loss of coolant in the collimator

Measurements to establish interlock params

- With cooling, the wire temperature as simulations: stable a few minutes after the current jump. Hottest spot at 120°C @ 350A
- Without cooling, tests at 100 – 200 – 300A:
  Tw <200-300°C for U_w < 2-3V.

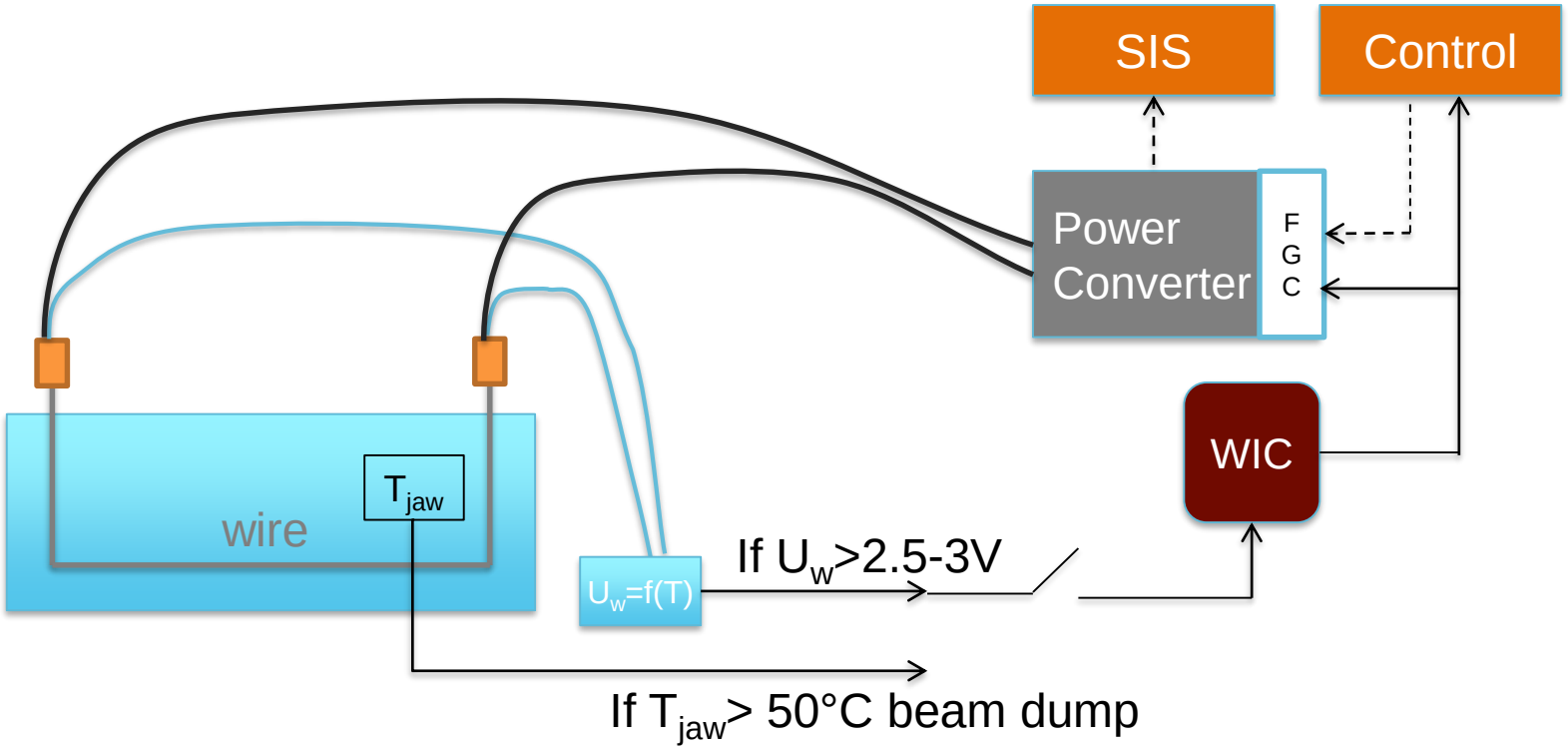




Prototype jaw used for wire testing and U_w(T) measurements under vacuum

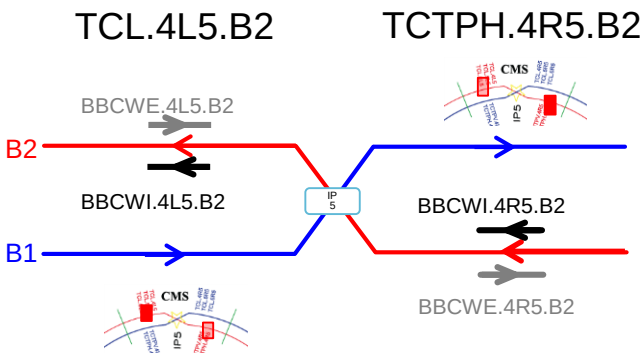
Wire protection and interlocks

Connection scheme

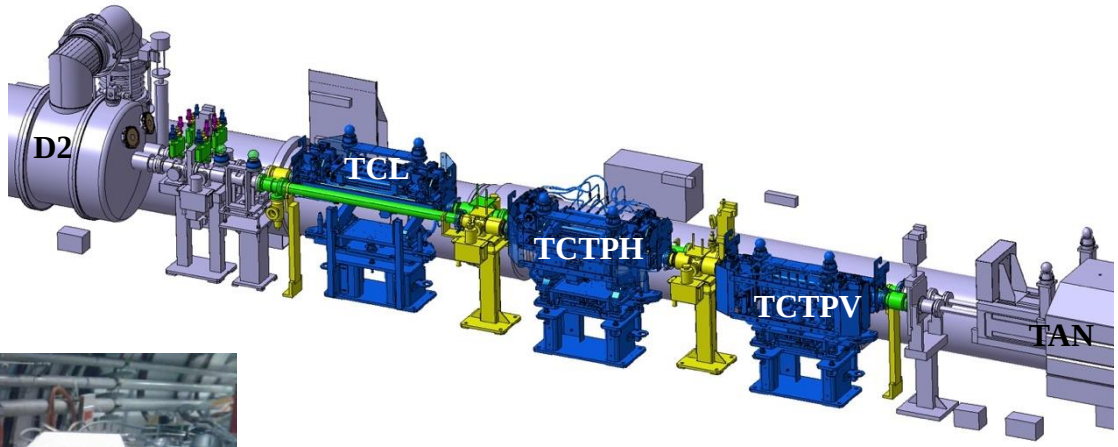


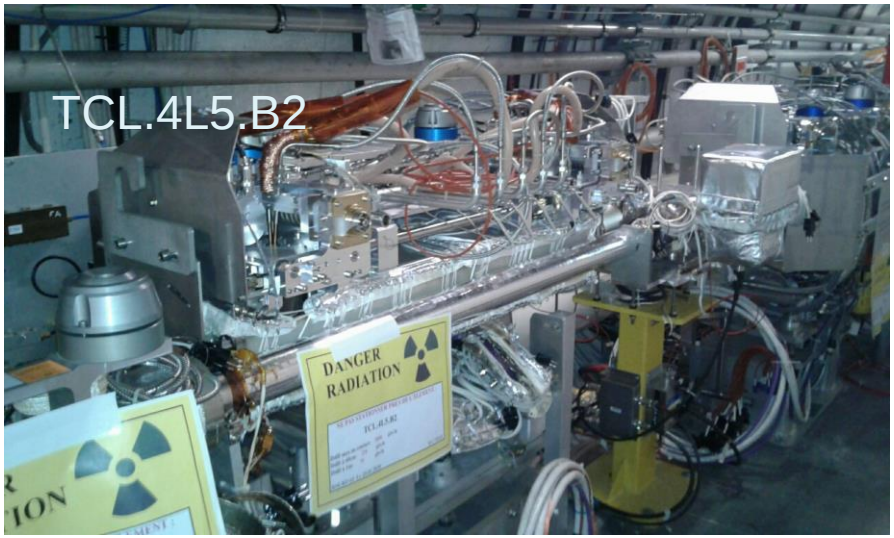
- If U_w>2.5-3V T_{max} wire 200-300°C ⟶ PC off via WIC
- If T_{jaw} > 50°C ⟶ beam dump

EYETS ’16-’17 – replacement of TCTPH.4R5.B2 and TCL.4L5.B2



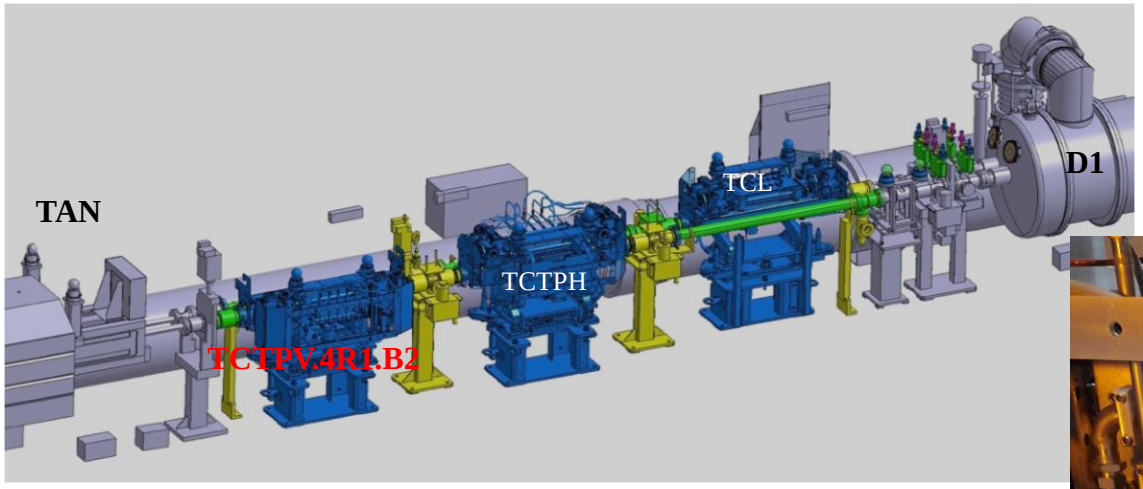
3D integration view: 4L5. (Symmetric view for 4R5)

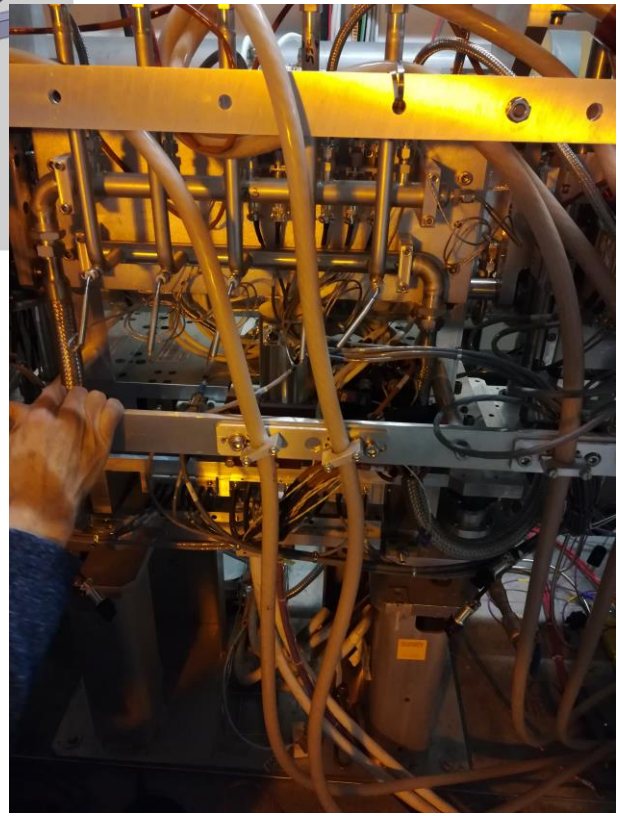


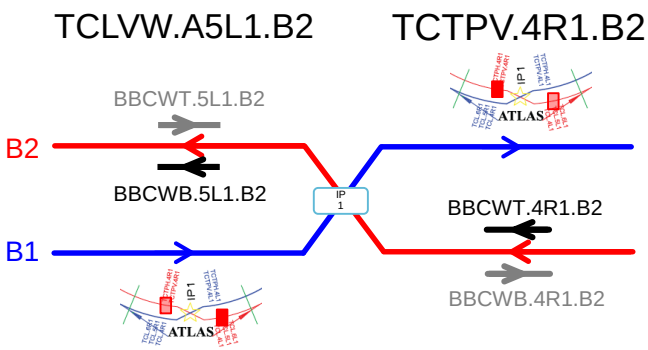


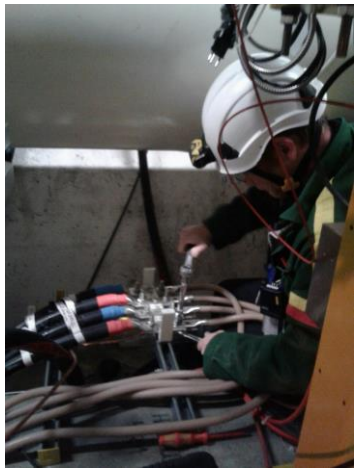
YETS ’17-’18 – replacement of interlock chassis

YETS ’17-’18 – replacement of TCTPV.4R1.B2

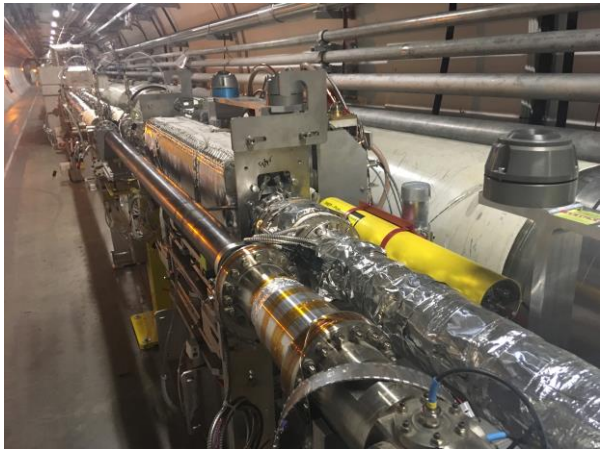


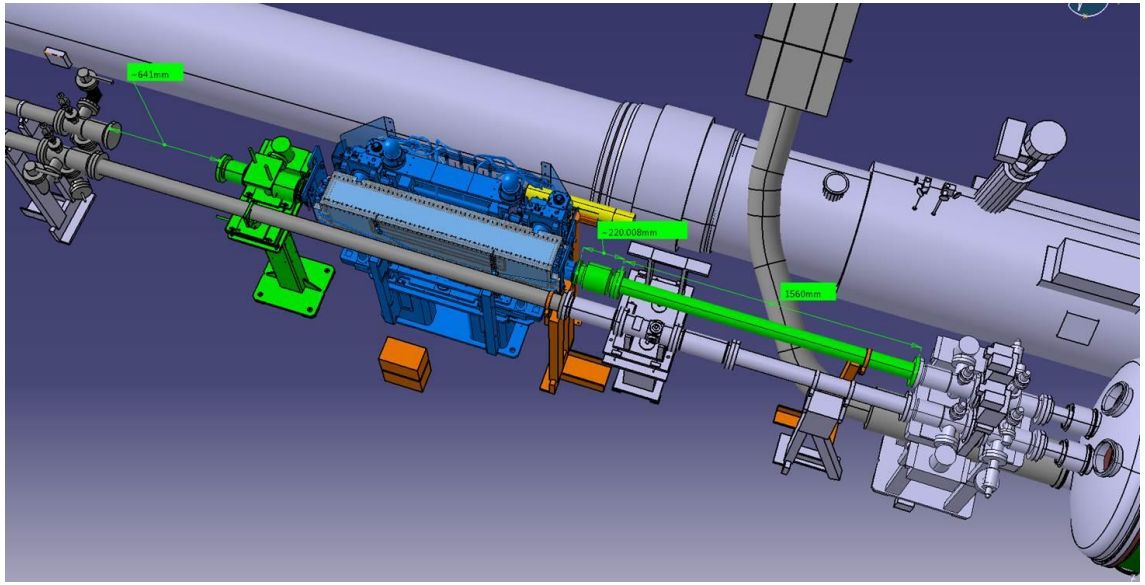


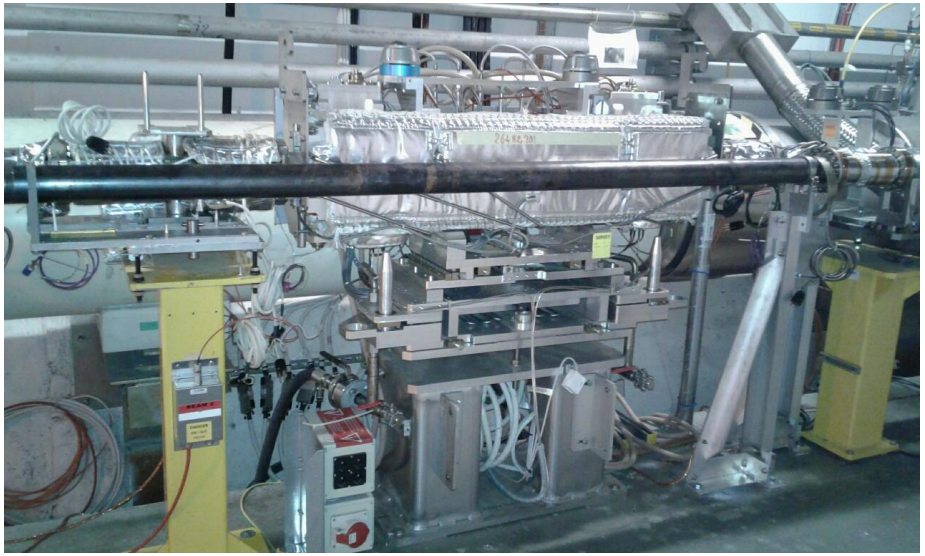


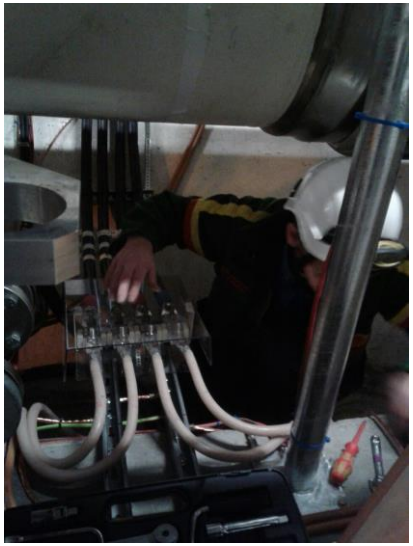


YETS ’17-’18 – installation of new vertical collimator TCLVW.A5L1

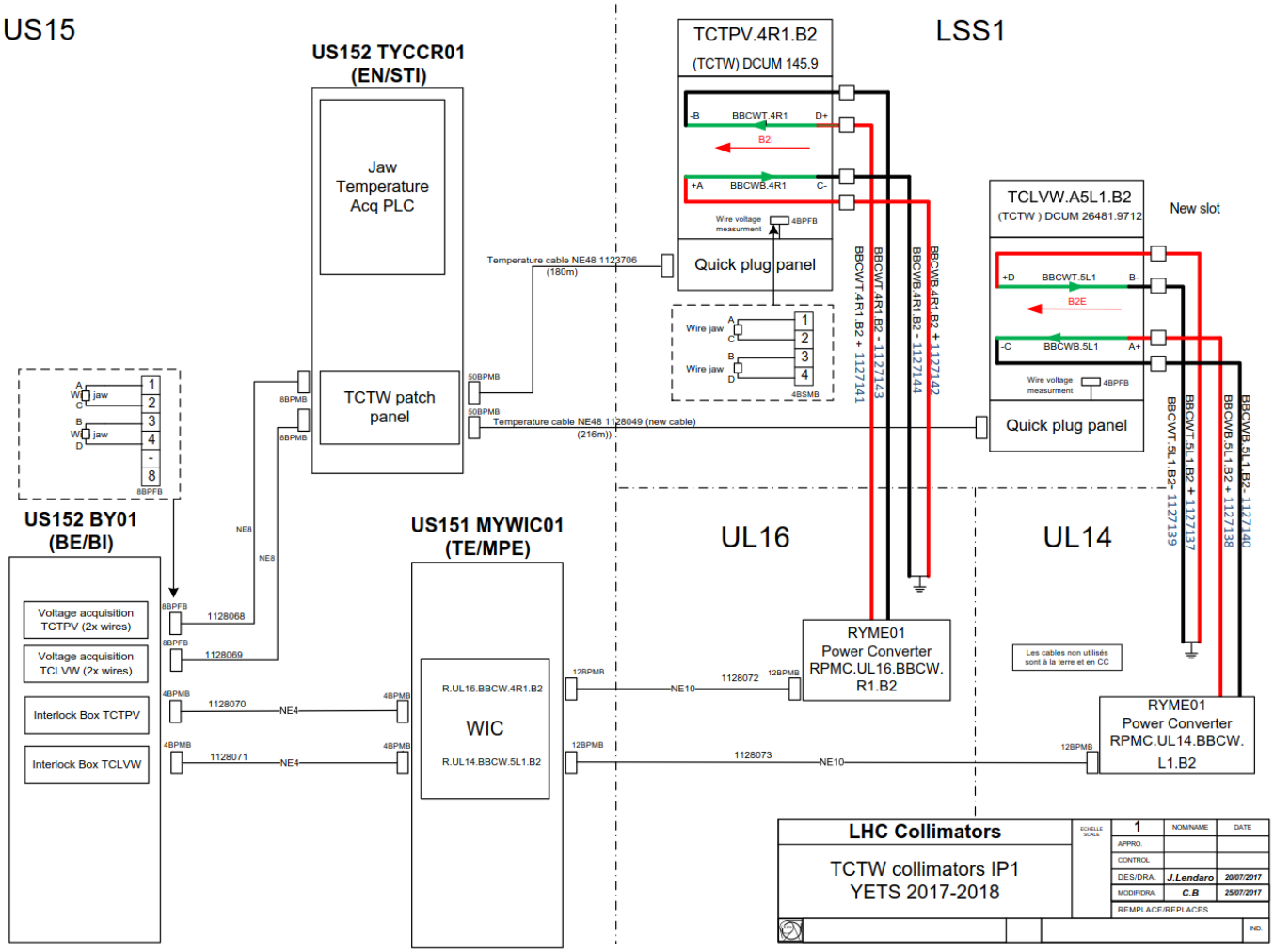




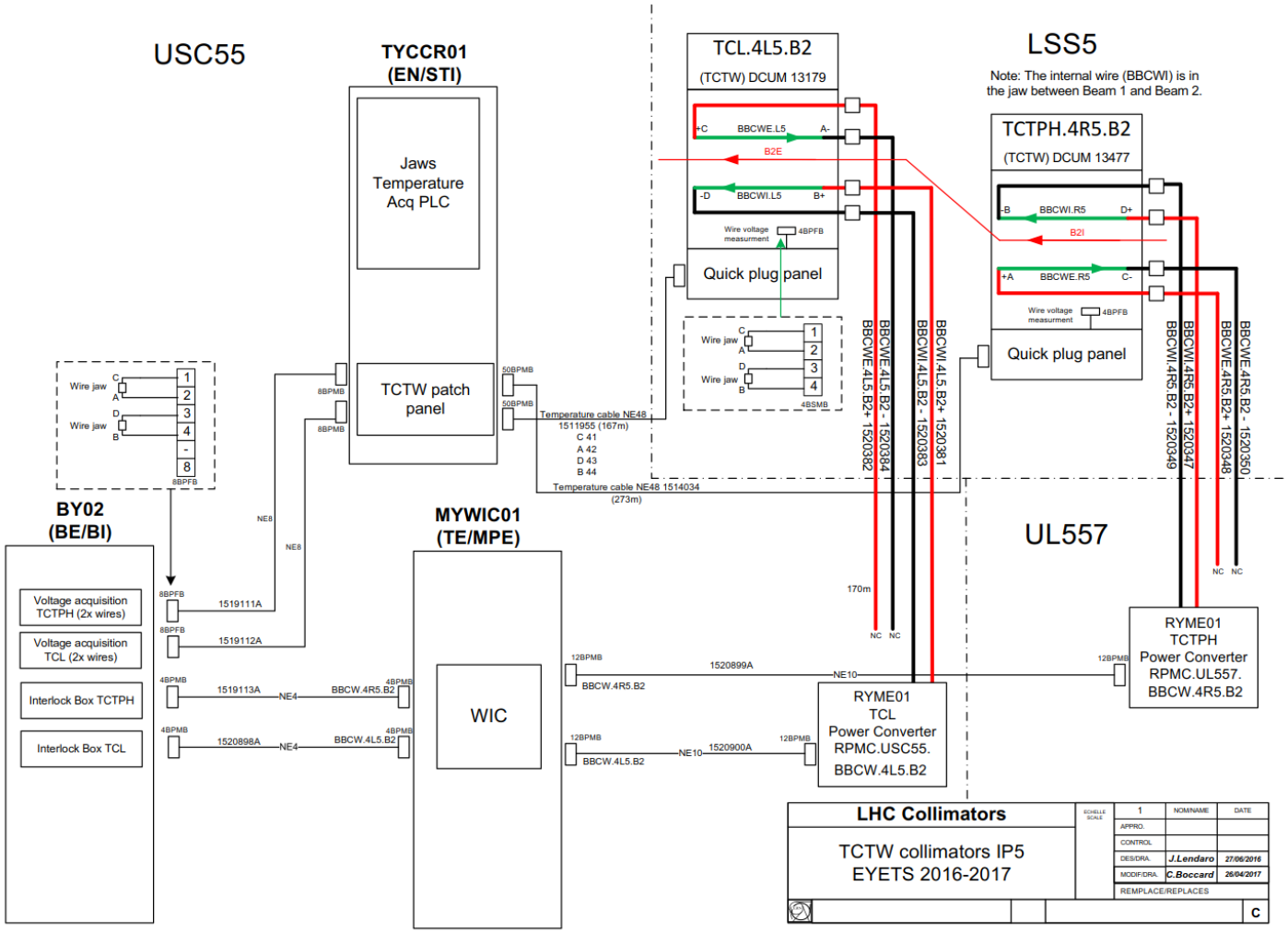




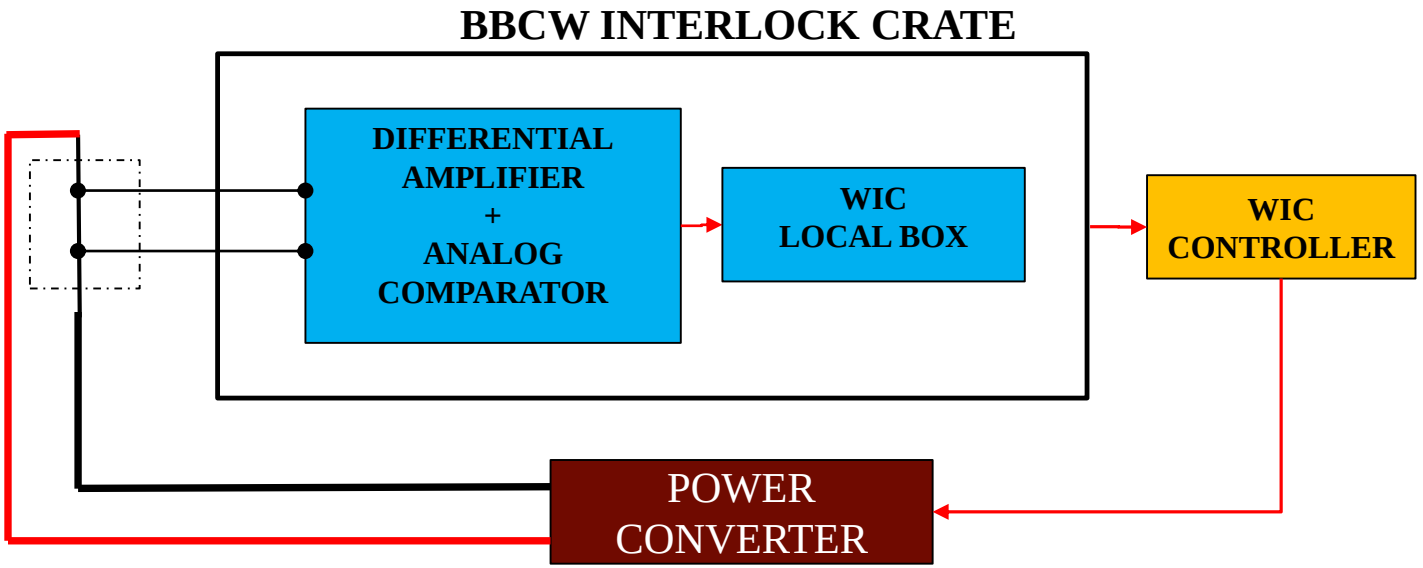
IR1 Control Layout

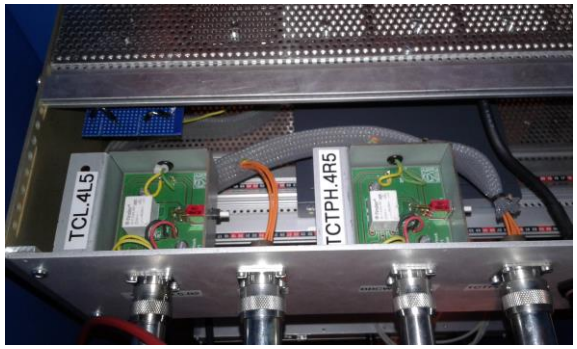


IR5 Control Layout



BBCW Interlock





- Interlock generated for BIPOLAR current
- THRESHOLD = 2.7V corresponds to
  - +/- 375A cooled (tested)
  - or ~200°C at hottest point on wire when loss of coolant
- FAIL SAFE SYSTEM :
  - Local power supply break
  - Cable removed
  - REDOUNDANCY (2 RELAYS) OUTPUT
- Well known basic electronics assembly
- 1 card per wire

Brief summary of commissioning IR1

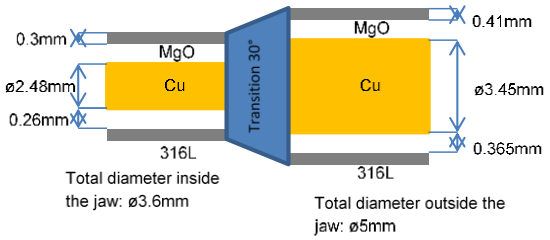
- Newly installed TCTW type collimators one replacing slot TCTPV.4R1.B2 and one new in slot TCLVW.A5L1.B2.
- WIC was commissioned and a wiring problem found fixed.
- Power converters had some issues solved by EPC.

TCTPV.4R1.B2 Both wires in jaws could be tested successfully:

- powering progressively up to ± 350A,
- checking the temperature at the connectors and change of cross-section,
- testing interlocks at ±375A, plus stability of 30min at 350A.
- moving the jaws fully in and out and the 5th axis at 350A.

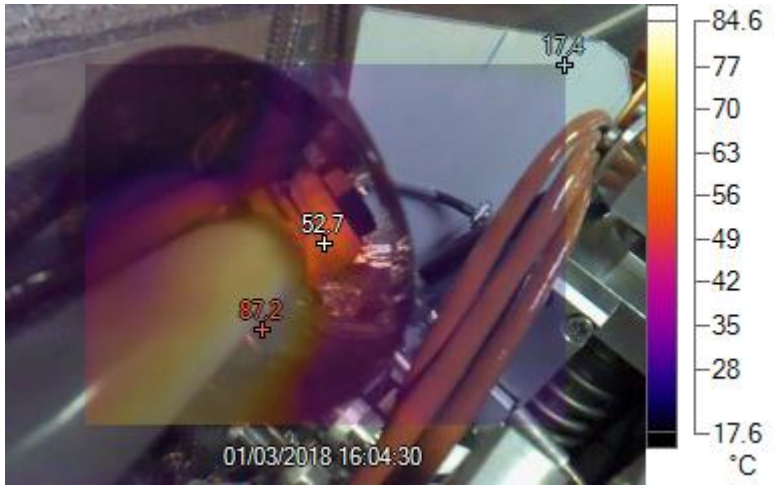
TCLVW.A5L1.B2 : Both wires in had a ground-fault that could be fixed

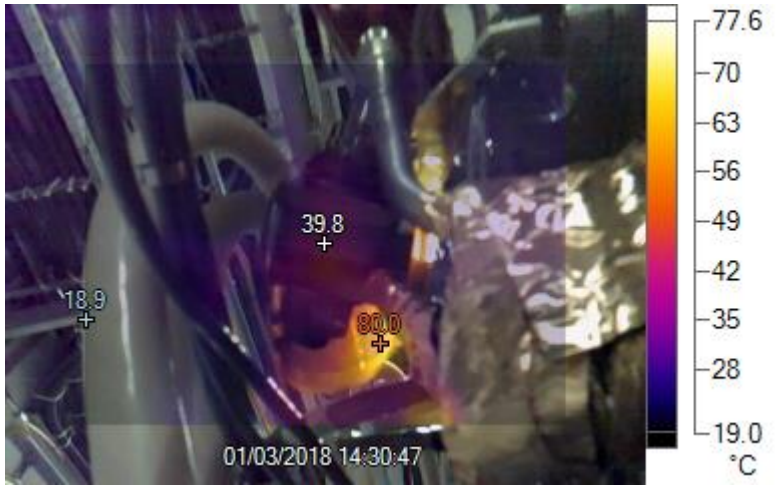
- after removing all connectors on the wires, the fault was found at the wire extremities where stripped to leave the bare copper wire for connection to powering. It was enough to slightly move the wire extremities for the fault to appear/disappear
- the wire was cleaned at the cut and a vacuum varnish was applied.



- Both wires were then tested as for 4R1 successfully.

Temperature at cable transitions in IR1



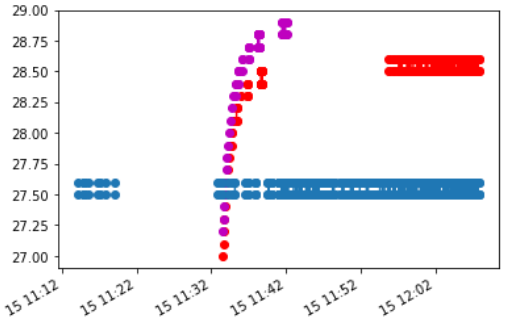


Brief summary of commissioning IR5

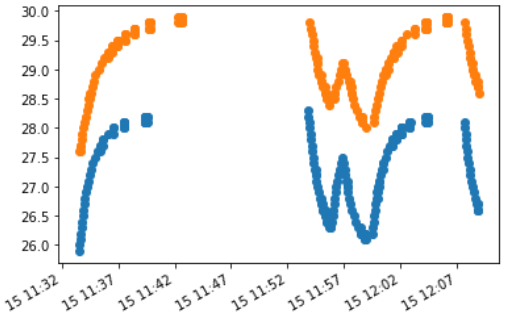
- Replacement of interlocks chassis to have a double polarity interlock on wire
- Power converters exhibited some erratic behaviour at negative current, which have disappeared after Laurent reset the FGC interface.
- Tested successfully at ±375A.
- Test that at ± 350A wire voltage remains < 2.7V even when heating up (jaw maximum temperature recorded in TCL after 45min 34°C stable)

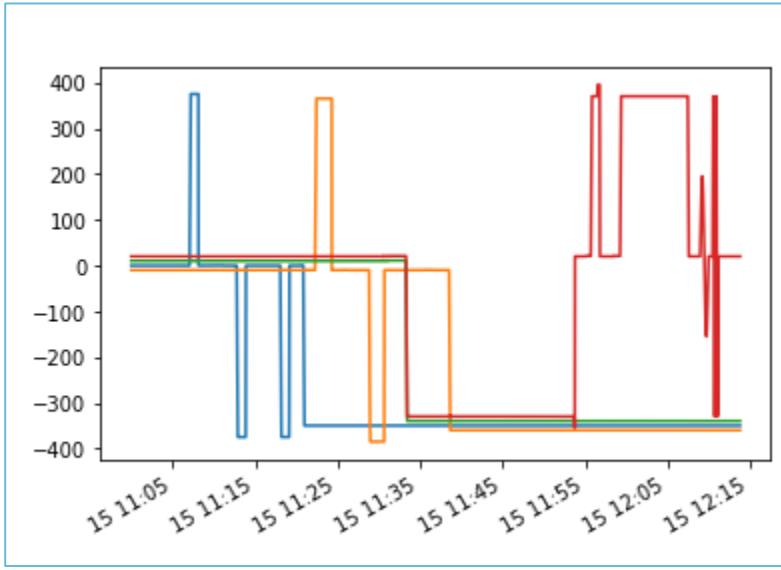
15 March tests: PC current and jaw temperatures

TCLVW.A5L1.B2



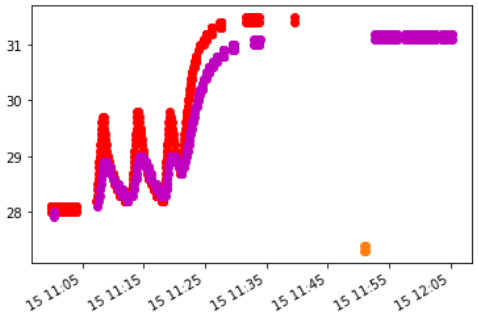
TCTPV.4R1.B2



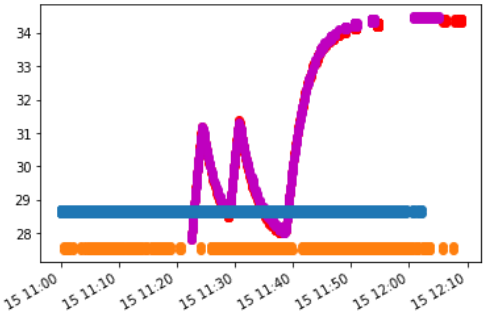


'RPMC.UL557.RBBCW.R5B2
'RPMC.USC55.RBBCW.L5B2
'RPMC.UL14.RBBCW.L1B2
'RPMC.UL16.RBBCW.R1B2

TCTPH.4R5.B2



TCL.4L5.B2

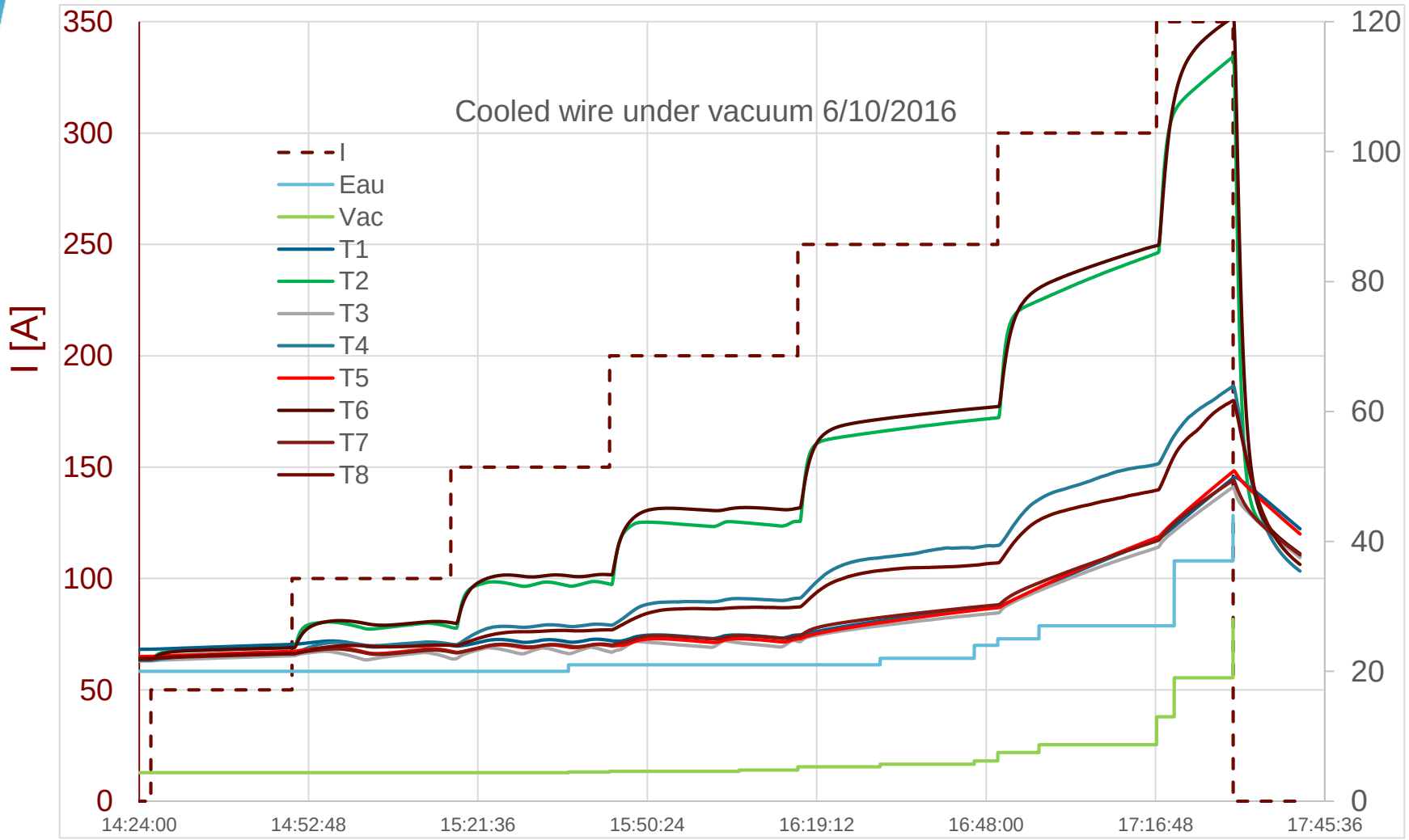


Conclusions

- Wire interlock now bipolar, fail-safe and redundant (tested only at start-up)
- All wires in IR1 new installation (from PC, WIC, cabling and wire itself, interlock) successfully commissioned
- Wires connected in IR5 (internal between beams) interlock successfully commissioned
- HW wire interlocks acts if $T_{w,hottest} > 200°C$ without coolant or at $\pm$ 375A
- SIS interlock fixed $\pm$ 355A non maskable.
- SIS interlock at $\pm$ 10A maskable to avoid unwilling operations.

Thank you for your attention

Wire T(I) – cooling on:
behaviour as expected but cooling not sufficient at I>200-250A



All temperature at 300A – no cooling

hottest part wire under vacuum, not in contact with jaw