



# Wire: Brief status of hardware/controls and tests done/to be done

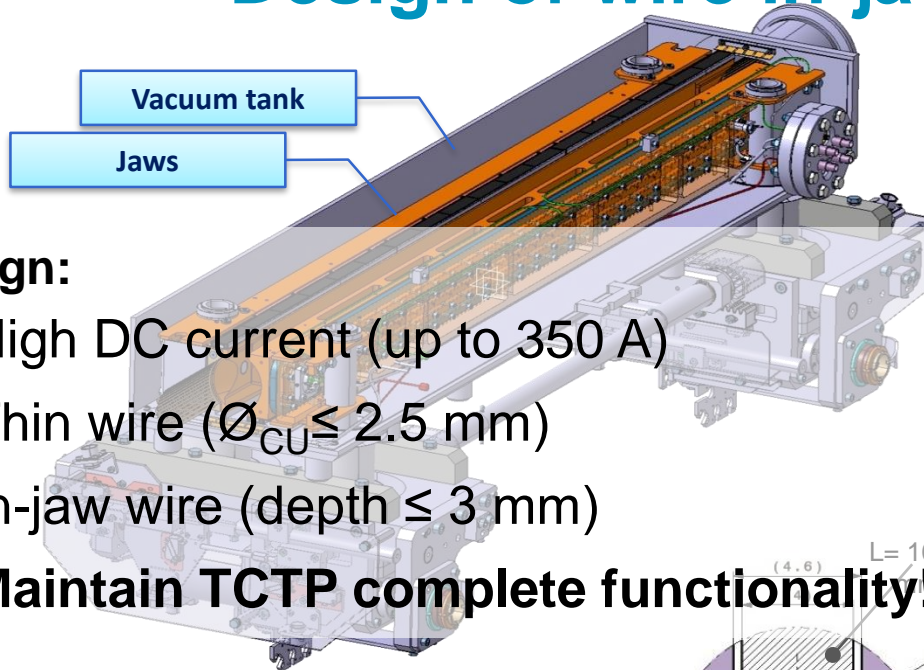
A. Rossi on behalf of (alphabetical):

*BE-ABP, BE-BI, BE-OP, EN-MME, EN-ACE, EN-STI, TE-EPC, TE-VSC*

# Outline

- Details on wire-in-jaw collimators and installation in EYETS 2016-17
- Prototype jaw tests and wire control logic
- Wire tests on the surface
- Wire tests in the tunnel
- Summary

# Design of wire in-jaw collimator

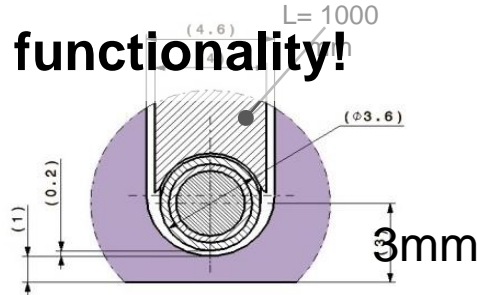
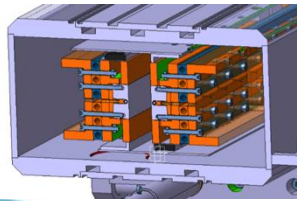


Vacuum tank

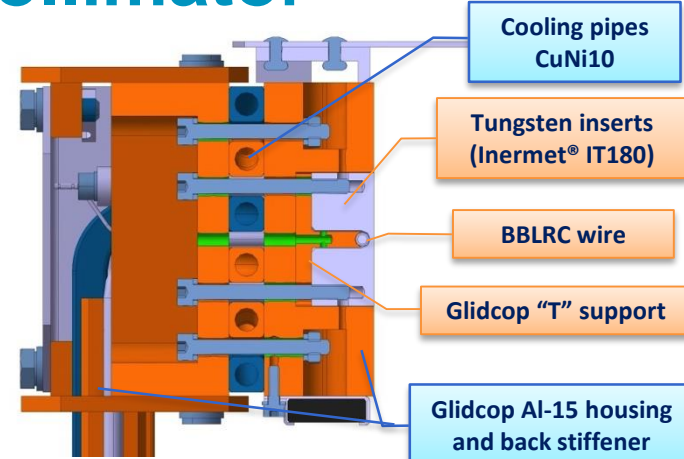
Jaws

## Design:

- High DC current (up to 350 A)
- Thin wire ( $\varnothing_{\text{Cu}} \leq 2.5 \text{ mm}$ )
- In-jaw wire (depth  $\leq 3 \text{ mm}$ )
- Maintain TCTP complete functionality!**



L. Gentini (EN-MME) & O. Aberle (EN-STI)



Cooling pipes  
CuNi10

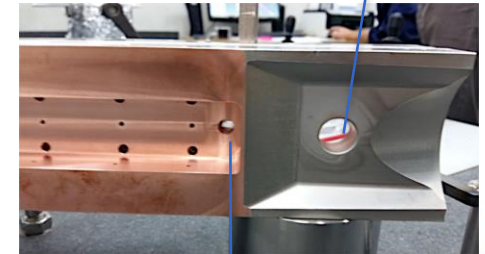
Tungsten inserts  
(Inermet® IT180)

BBLRC wire

Glidcop "T" support

Glidcop Al-15 housing  
and back stiffener

BPM button housing

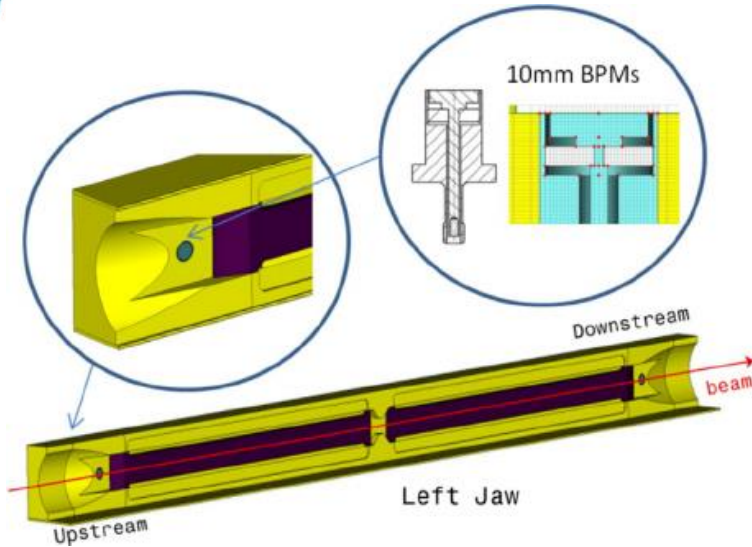


Holes for wire

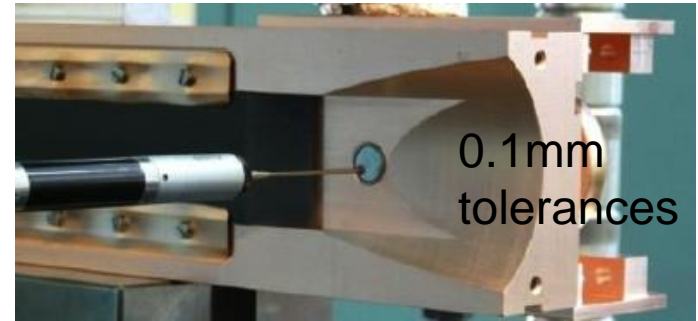
# Wire-in-jaw collimators

- Wire moving in H plane = same as beam crossing (for non-flat beam)
  - step size of 5  $\mu\text{m}$
  - accuracy < 50 $\mu\text{m}$
  - position measured with LVDTs, absolute with calibrated end-switches (metrology)
- Possibility to move the wire in perpendicular plane (collimator 5<sup>th</sup> axis) to adjust for orbit offset
  - step size < 5  $\mu\text{m}$  (1/10 of the torch)
  - position measured with LVDTs
- Current up to 350A + cooling

# Embedded jaw BPM



D. Wollmann et al, <http://dx.doi.org/10.1016/j.nima.2014.09.024>

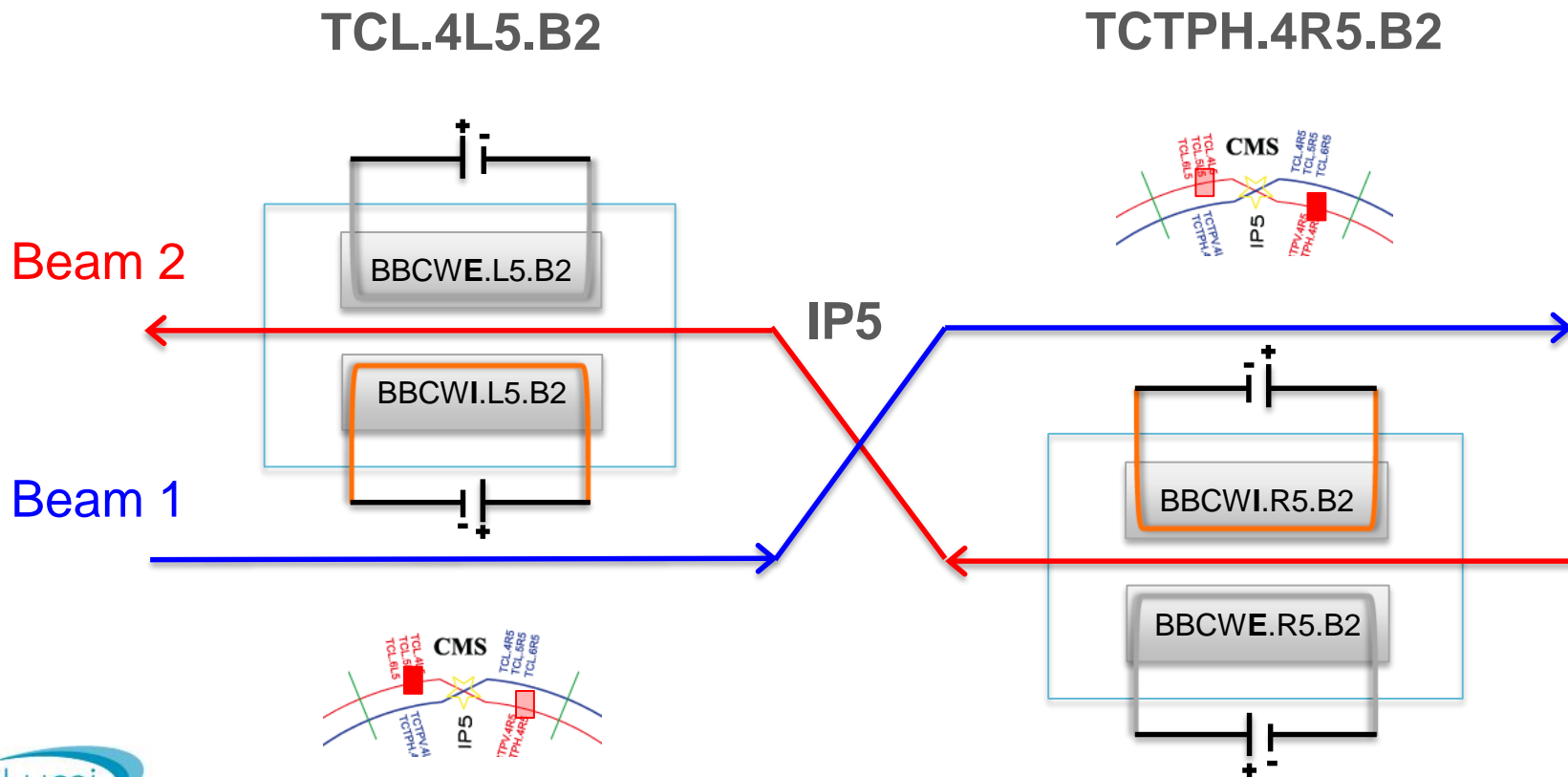


Metrology control of jaw mock-up to check the alignment of the BPM button surface with respect to the surrounding tapering

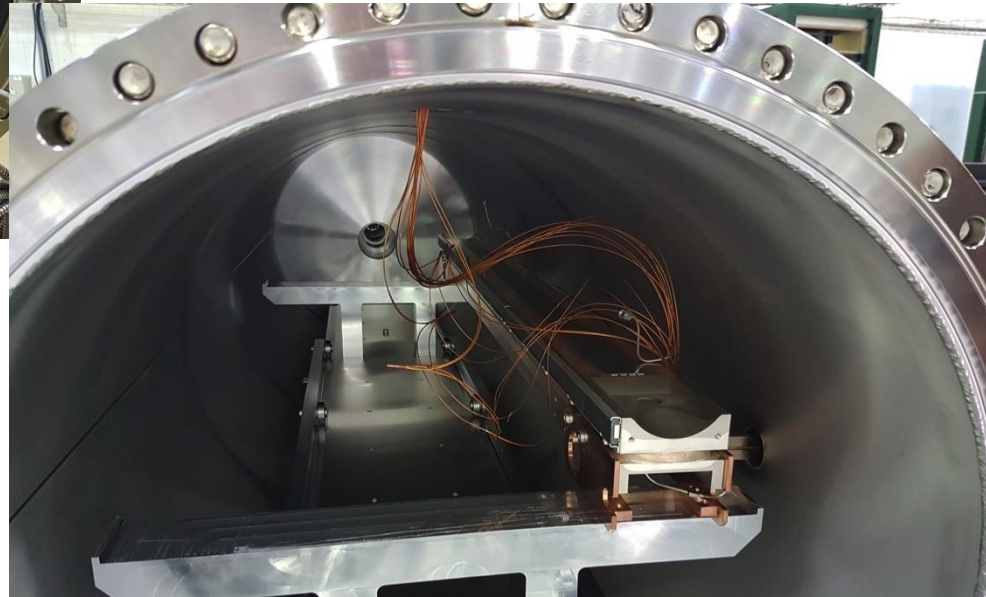
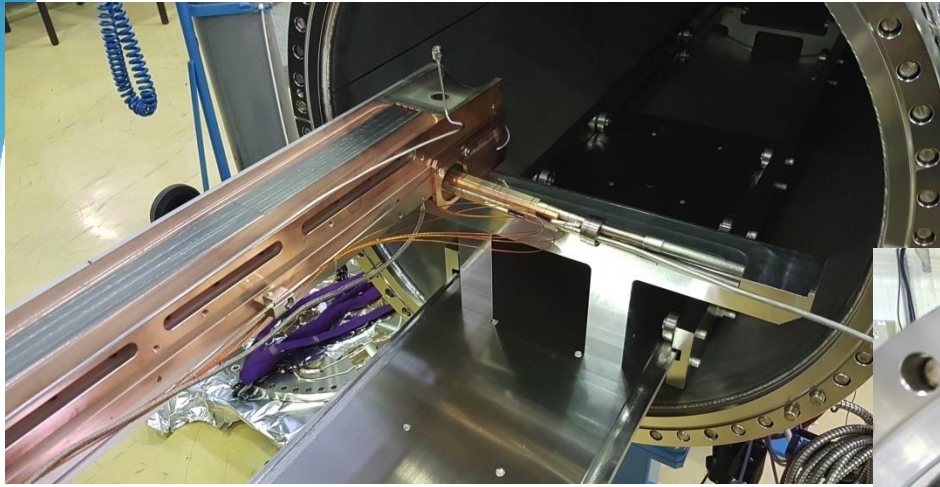
A. Dalocchio, IPAC-2011

Beam-wire vertical alignment done by moving 5<sup>th</sup> axis and scanning with BPM (beam size ~ 0.3 to 1mm) @ zero wire current

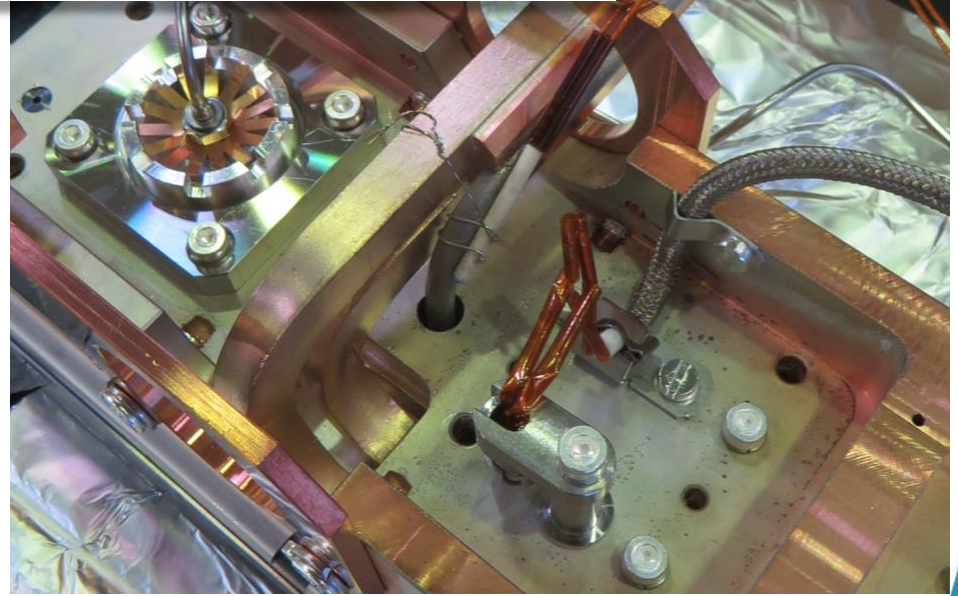
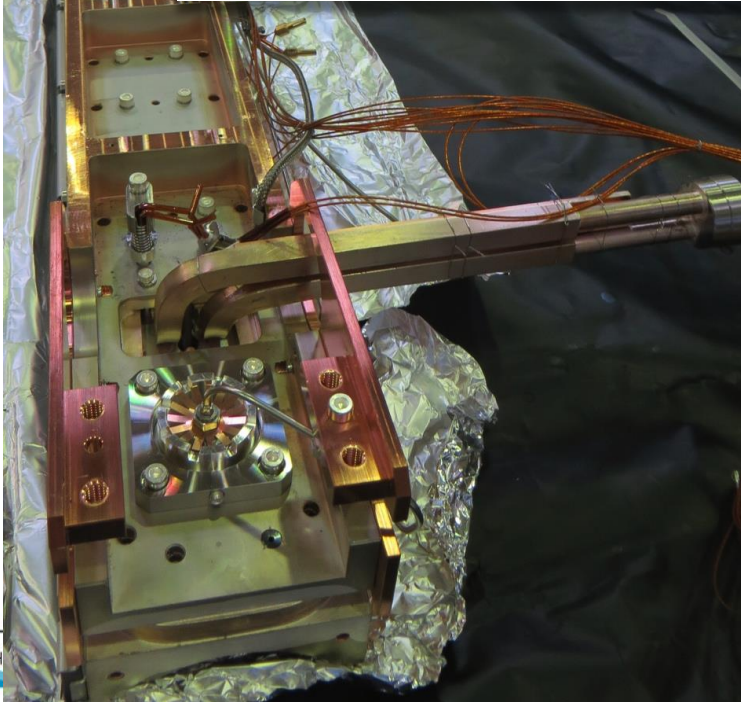
# In-jaw wire collimators installed during EYETS 2016-17



# Prototype jaw for lab tests



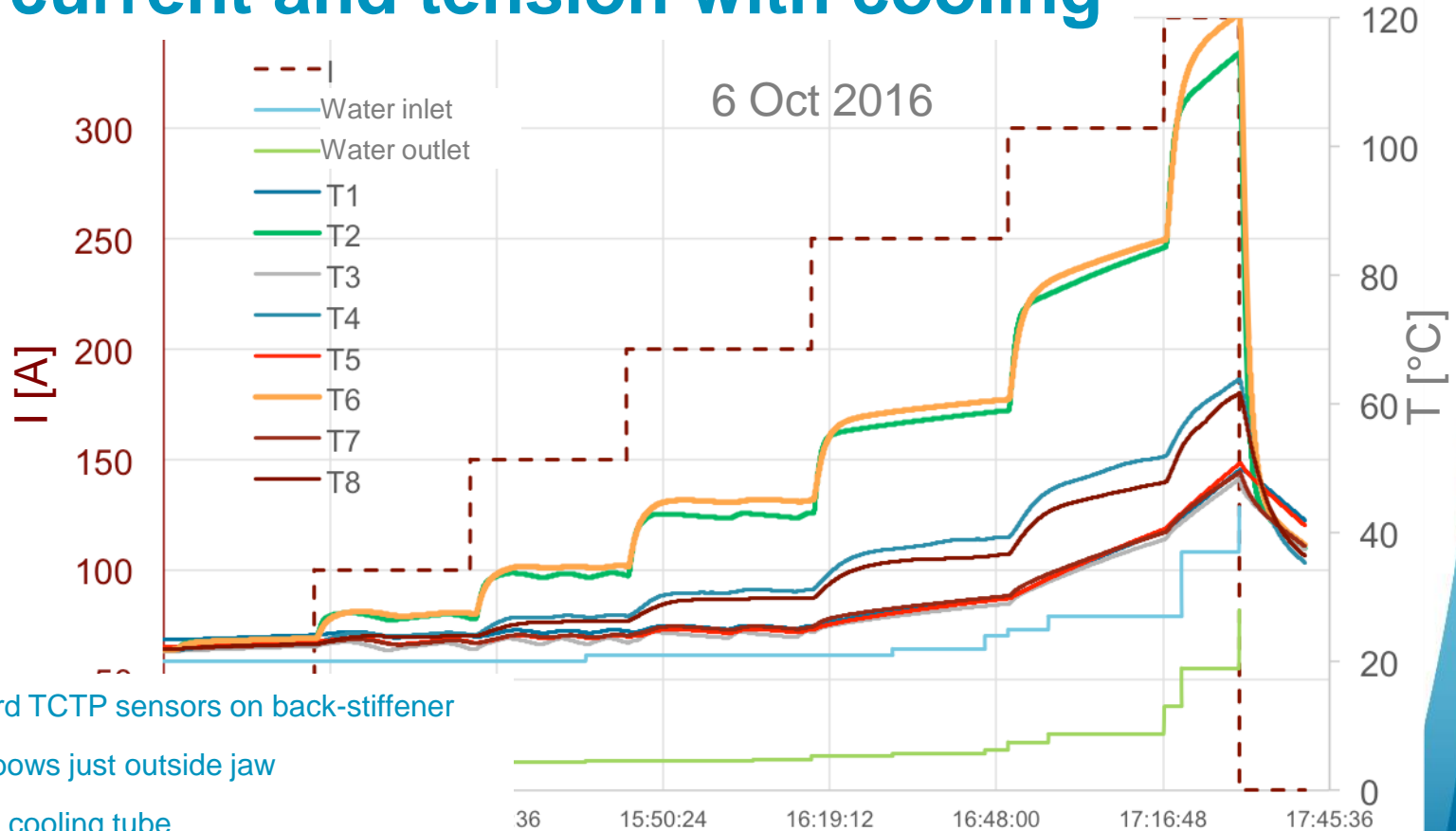
- ✧ T1 et T5 : standard TCTP sensors on back-stiffener
- ✧ T2 et T6 : wire elbows just outside jaw
- ✧ T3 et T7 : wire on cooling tube
- ✧ T4 et T8 : next to flange brazing





# Wire current and tension with cooling

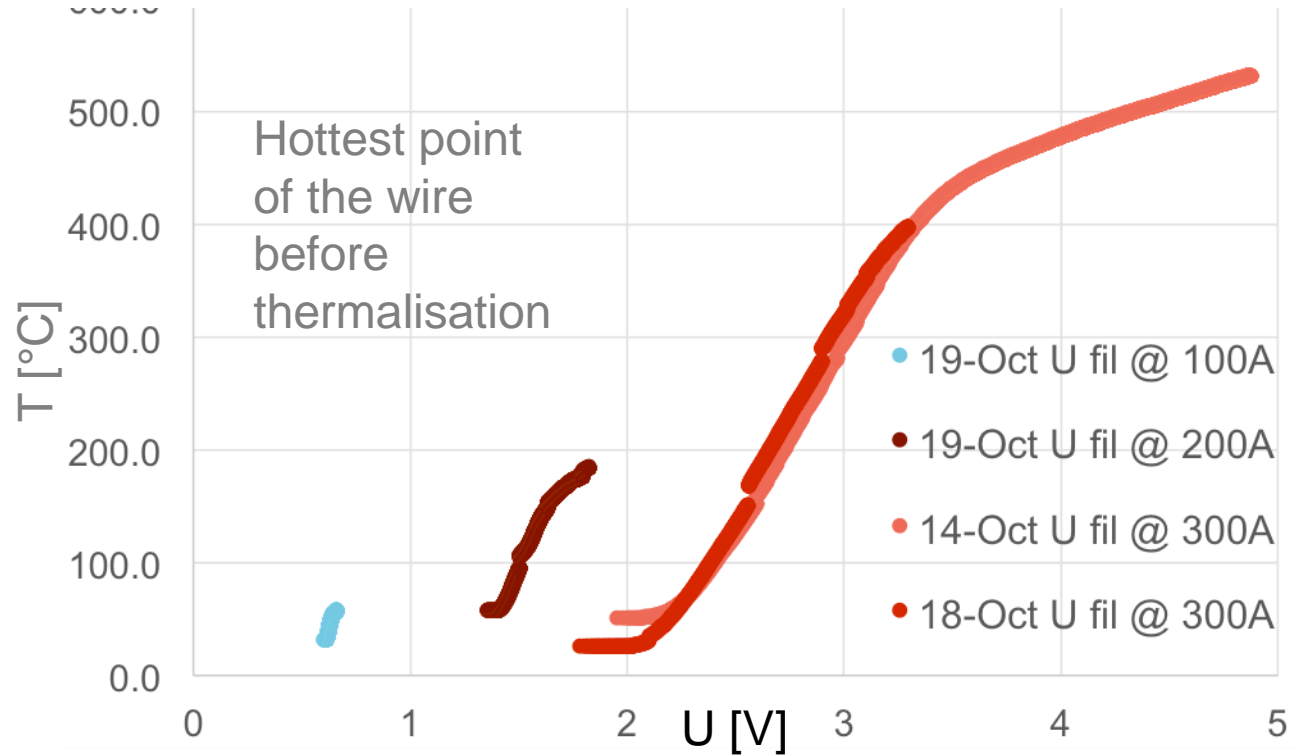
Measurements confirmed by simulations



- ◇ T1 et T5 : standard TCTP sensors on back-stiffener
- ◇ T2 et T6 : wire elbows just outside jaw
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# Wire temperature and tension without cooling

U	=	R @ 50°C	x	I
0.63	=	6.30E-03	x	100
1.26	=	6.30E-03	x	200
1.89	=	6.30E-03	x	300
U	=	R @ 200°C	x	I
0.98	=	9.80E-03	x	100
1.96	=	9.80E-03	x	200
2.70	=	9.00E-03	x	300



By limiting the wire tension we avoid overheating in case of loss of cooling

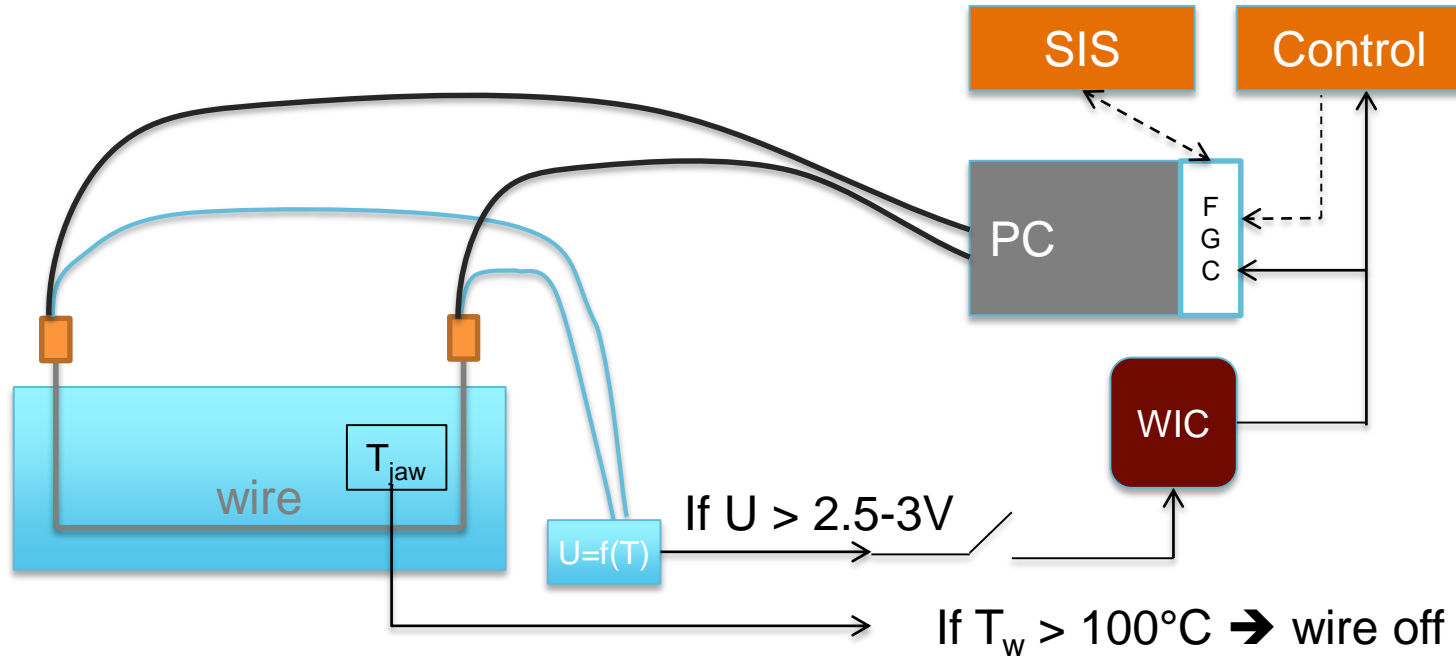
# If wire on accidentally during standard LHC operations

- The maximum kick  $<$  beam-beam effect, which so far has not caused any machine protection issues
- SIS interlock on the status of the PC

$\Delta r' = -\frac{B_w L_w}{(B\rho)}$ $B_w = \frac{\mu_0 I_w}{2\pi r}$	TCT.4R5.B2		TCL.4L5.B2	
	Injection energy	Collision energy	Injection energy	Collision energy
$\beta$ at collimator (m)	159	2148	79	772
$\sigma$ (mm)	1.08	1.04	0.76	0.62
collimator setting ( $\sigma$ )	13	9	25	15
r (mm)	17.00	12.38	21.98	12.37
B (T)	3.53E-03	4.85E-03	2.73E-03	4.85E-03
$\Delta r'$ ( $\mu$ rad) @ 300A	2.61	0.25	2.02	0.25
$\sigma'$ ( $\mu$ rad)	6.77	0.48	9.61	0.81
ratio $\Delta r'/\sigma'$	0.39	0.51	0.21	0.31

- [LHC RunII pp physics – injection, optics 2016](#)
- [LHC Run II pp physics – Collision \(0.4m\), optics 2016](#)

# Wire protection and interlocks



- RBAC role to expert only
- SIS wire NOT-ON if beam in – to be masked during MD

# Hardware readiness

- Wire tests on the surface
  - Collimator under pumping (after bake-out) and with cooling on:
    - LVDTs reading when wire @ 350A : no sensitivity observed
    - Pressure when wire @ 350A :  $\sim 10^{-8}$  mbar
    - Jaw temperature  $< 50^{\circ}\text{C}$
    - Wire temperature outside collimator tank  $\sim 300^{\circ}\text{C}$  after thermal bridge adjusted
- Both collimators installed
- TCTPH bake-out + standard commissioning completed
- TCL bake-out to be repeated next week due to a leak in the sector

# Wire tests in the tunnel

- **Pre-conditions:**
  - Standard collimator commissioning completed + water cooling on
  - Power Converters tested (ET-EPC) – circuit loop charge, current ripple and overshoot.
  - Remote control of the PC and read-out of the wire tension, jaw temperature and sector pressure
- **Wire tests (for the moment planned for Wednesday 22 March for TCTPH and in about 2wks for TCL) on both INTERNAL and EXTERNAL wires:**
  - WIC and control interlocks
  - Zero current
    - Reading of the voltage and checking the 10V common mode voltage
    - Check for PC noise
  - Remote powering to 100A
    - Check overshooting (with oscilloscope)
    - Measure wire external temperature (infrared camera)
    - Measure wire voltage for calibration of signal to WIC
  - Remote powering to 350A (at specified ramp rate)
    - Check overshooting (with oscilloscope)
    - Check for induced signals on pick-ups during ramp
    - Measure wire voltage for calibration of signal to WIC (retest WIC)
    - Check LVDTs
    - Move jaws H and 5<sup>th</sup> axes

# Summary

- TCTW : 350A wire moving in crossing plane and perpendicular (5<sup>th</sup> axis)
- Wire tested in prototype jaw to define interlocks
- TCTW tested on surface successfully
- Collimators (H) installed in IR5:
  - TCTPH.4R5.B2 bake-out + standard commissioning completed – Wire commissioning on Wed 23/03/17
  - TCL.4L5.B2 to be baked out next week



*Thank you for your attention  
and thank you to all contributors*

Possibly not all :

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BE-BI: H.Schmickler, J.Albertone, C.Boccard, M.Gonzalez Berges, R.Jones . . .

BE-OP: M.Pojer . . .

EN-MME: A. Bertarelli, A. Dallochio, M. Garlasche, L.Gentini, F.Carra . . .

EN-STI: O.Aberle; I.Lamas Garcia; J.Lendaro; M.Di Castro . . .

EN-ACE: D.Tortrat, JF.Fuchs . . .

TE-EPC V.Montabonnet, C.Coupat, L.Ceccone, M.Magrans de Abril, Q.King . . .

TE-MPE: R.Mompo, D.Wollmann, M.Zerlauth, J.Uythoven

TE-VSC: G.Cattaneoz, G.Bregliozzi . . .



# Test: temperature evolution with jaw under vacuum and cooling off + wire tension.

