Electropolishing of large copper substrates for FCC

FCC-ee 400 MHz double cell

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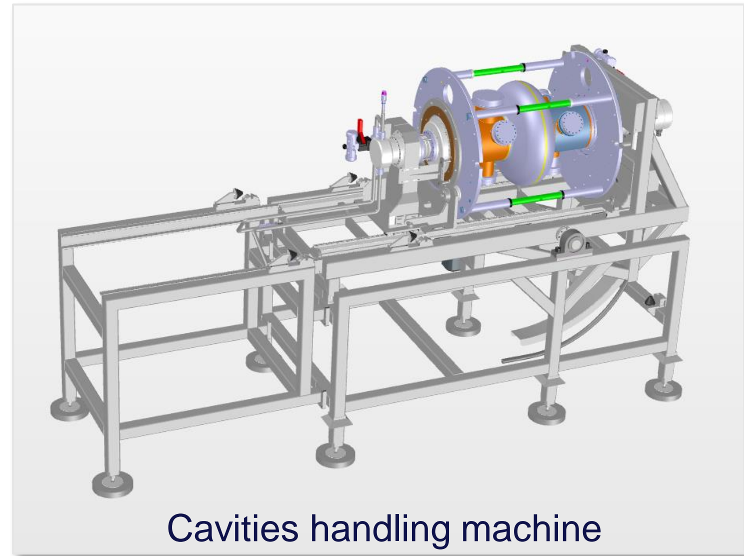
Tools and expertise

Electropolishing set-up & Interfaces

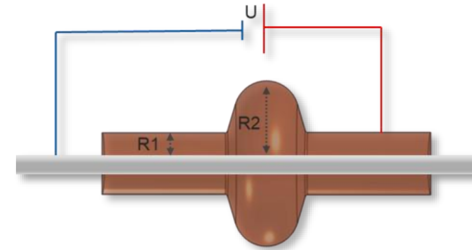
Bath handling chemical facility



Cavities handling machine

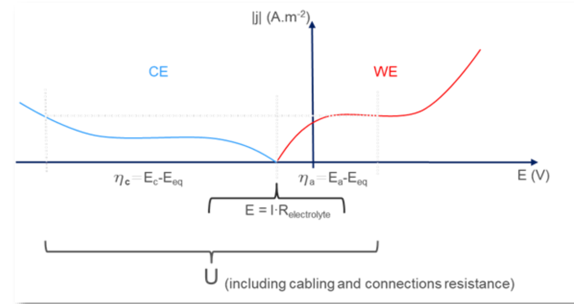
Tools and expertise

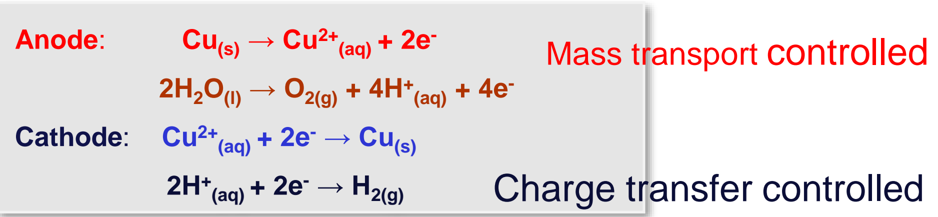
- Simulation



working parameters

$j = f(U, T, v_b, S_c/S_a, \sigma_l, [b])$
- j, Current density
- U, Overall applied tension
- T_b, Bath temperature
- v_b, Bath fluid dynamics
- Sc/Sa, **Cathode geometry** & Cathodic/Anodic surface ratio
- σ_l, Bath conductivity
- [b], Bath composition





Anode: $Cu_{(s)} \rightarrow Cu^{2+}_{(aq)} + 2e^-$

$2H_2O_{(l)} \rightarrow O_{2(g)} + 4H^+_{(aq)} + 4e^-$

Mass transport controlled

Cathode: $Cu^{2+}_{(aq)} + 2e^- \rightarrow Cu_{(s)}$

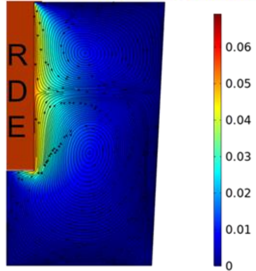
$2H^+_{(aq)} + 2e^- \rightarrow H_{2(g)}$

Charge transfer controlled

Tools and expertise

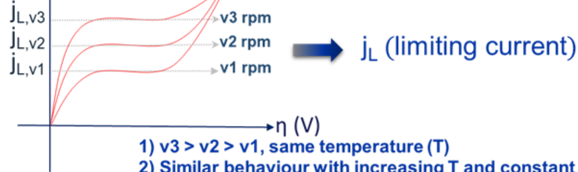
- Simulation

Bath velocity magnitude (m/s)

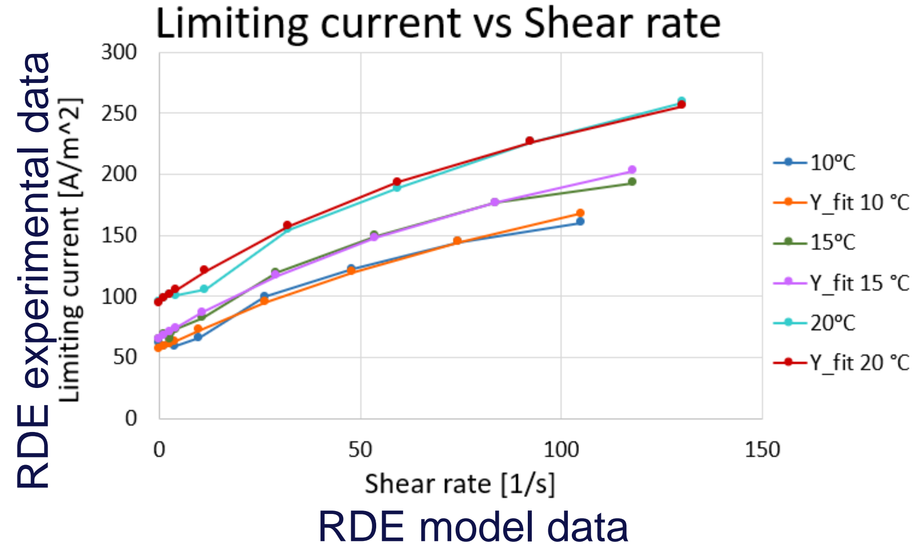


Shear rate

$$\tau = \sqrt{\left(\frac{\partial u}{\partial z}\right)^2 + \left(\frac{\partial v}{\partial z}\right)^2}$$



Shear rate (τ) is the rate of change in velocity at which one layer of fluid passes over an adjacent layer

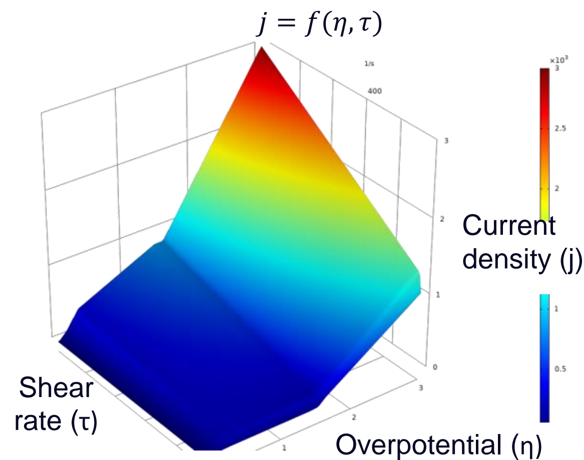


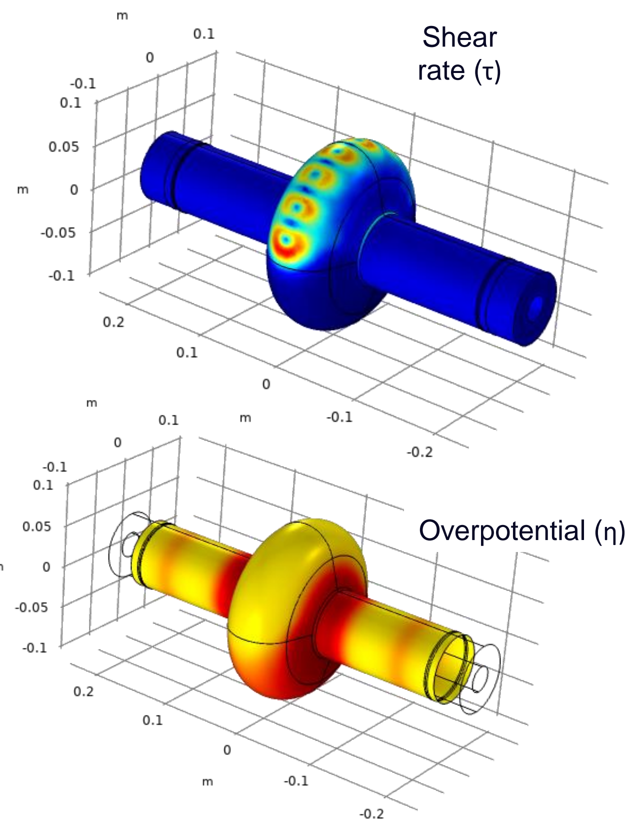
Tools and expertise

- Simulation

Creation of a new anodic current density function to be used for any geometry, using the results obtained with the RDE:

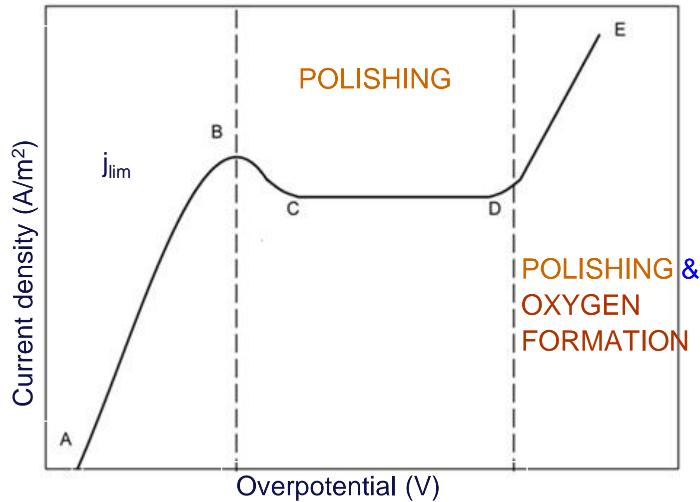
$$j = f(\eta, \tau)$$

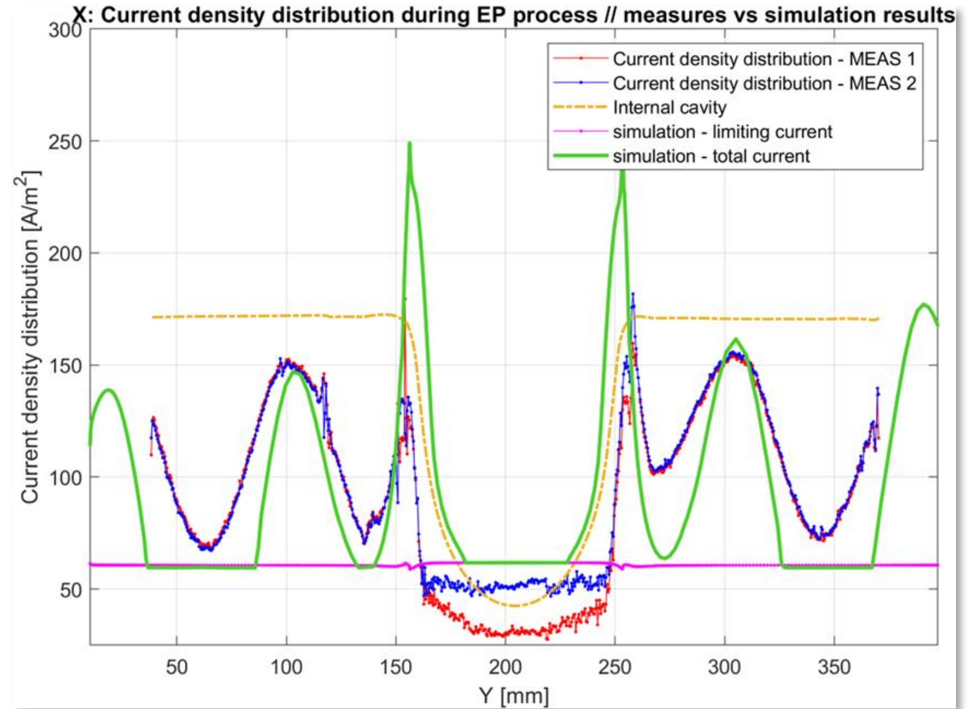




Simulation vs Real data

- Benchmarking on **1.3 GHz** copper monocell

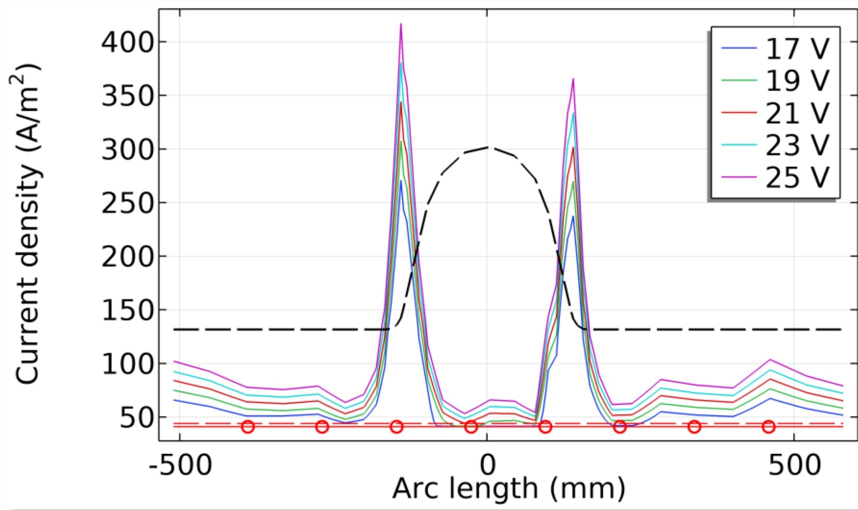




Simulation vs Real data

- Data from simulation:

400 MHz Current density distribution at 10 °C



Simulation total current, corrected to estimated wet surface: **84 A** at 21 V

- Data from **400 MHz** monocell processing

Cavity	Tension / V	Current / A	Temperature / °C *
PC04#1	21	81.8	15.4
PC04#2	21	72.5	14.0
PC06#1	21	75.0	15.2
PC06#2	21	75.9	14.8

*) Temperature readings from the chemical facility are not in line with the ones measured on the test cavity (~**10 °C**). dT within the chemical facility is below 1.6 °C.

Average polishing rate: **0.1 µm/min**

Main issues and achievements

1st Ever electropolishing of a 400 MHz monocell copper cavity

1st Ever electropolishing of a 400 MHz LHC monocell copper cavity

Main issues and achievements

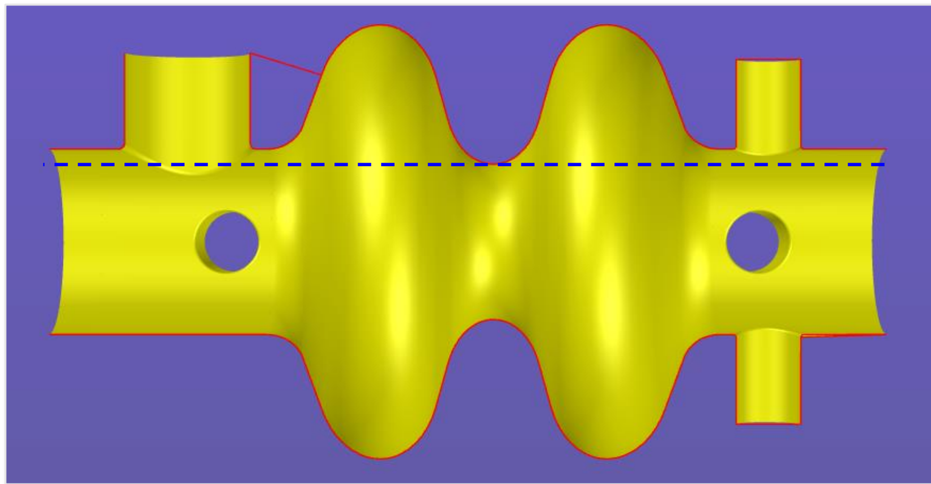
Main issue: Passivate the copper

Neutralisation before disassembly

Preparation for the 2-cells 400 MHz FCC-ee cavities

Main challenges

- Power input (+ surface & + distance)



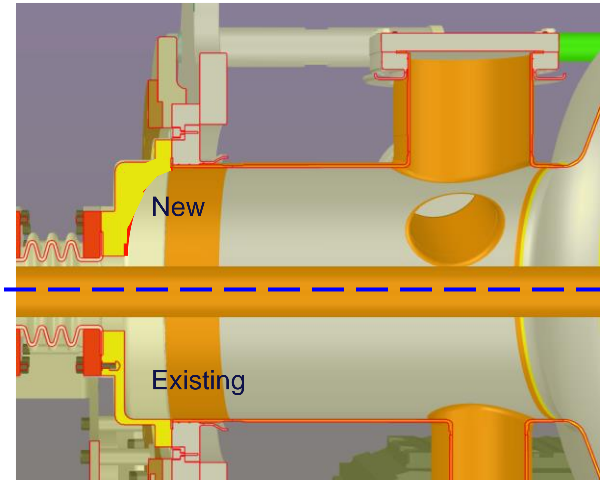
Strategy

- Cathode optimisation
- Increase bath flow
- Exploit existing working window

Preparation for the 2-cells 400 MHz FCC-ee cavities

Main challenges

- Passivation of copper



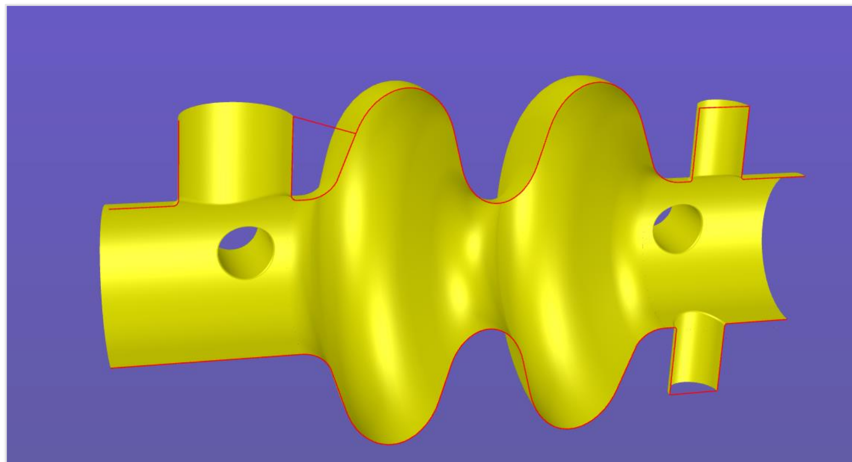
Strategy

- Reduce retentions
- Reduce back flow
- Keep neutralisation step

Preparation for the 2-cells 400 MHz FCC-ee cavities

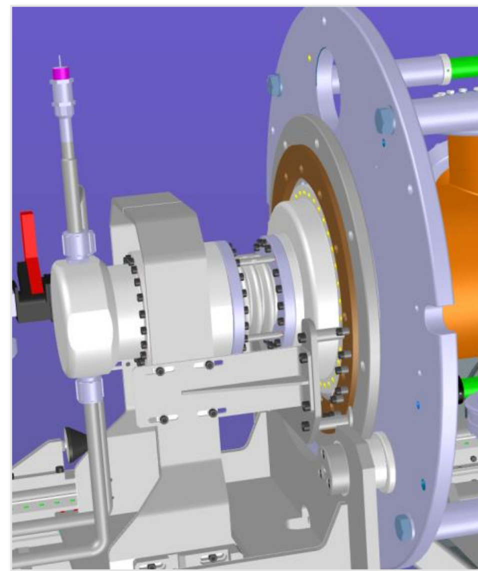
Main challenges

- Electropolishing of ports



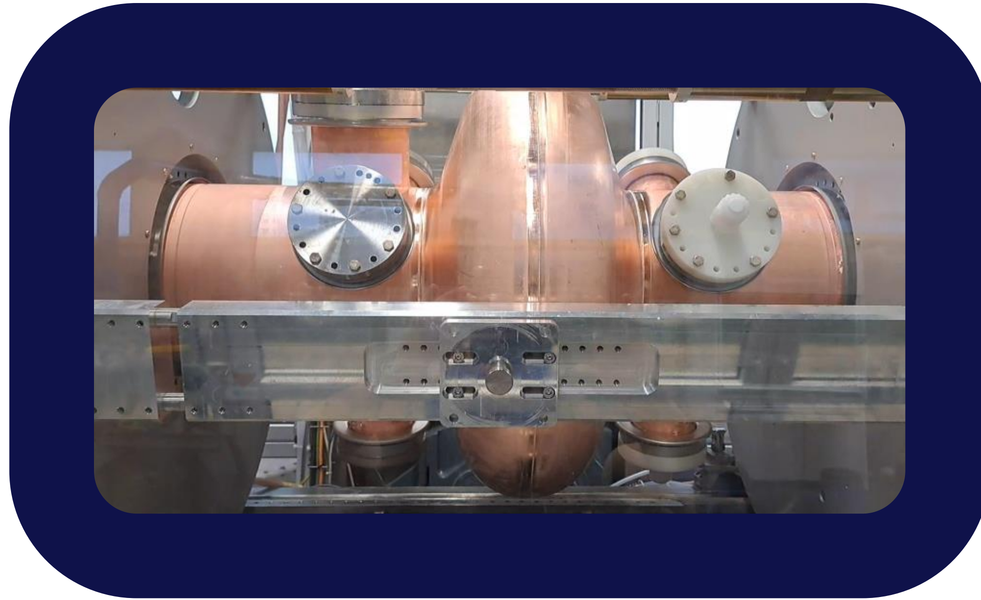
Strategy

- Assemble 2nd contact ring



Conclusions

- Electropolishing process is well mastered
- Data from 400 MHz monocell processing ensures 2-cell geometry EP feasibility
- Main challenge remains the copper surface passivation
- Impact of non electropolished (EP) ports still to be assessed



Thank you for your attention