Romanian HSSIP 2021

Project 9: Life cycle of a component of an accelerator (crab cavities)

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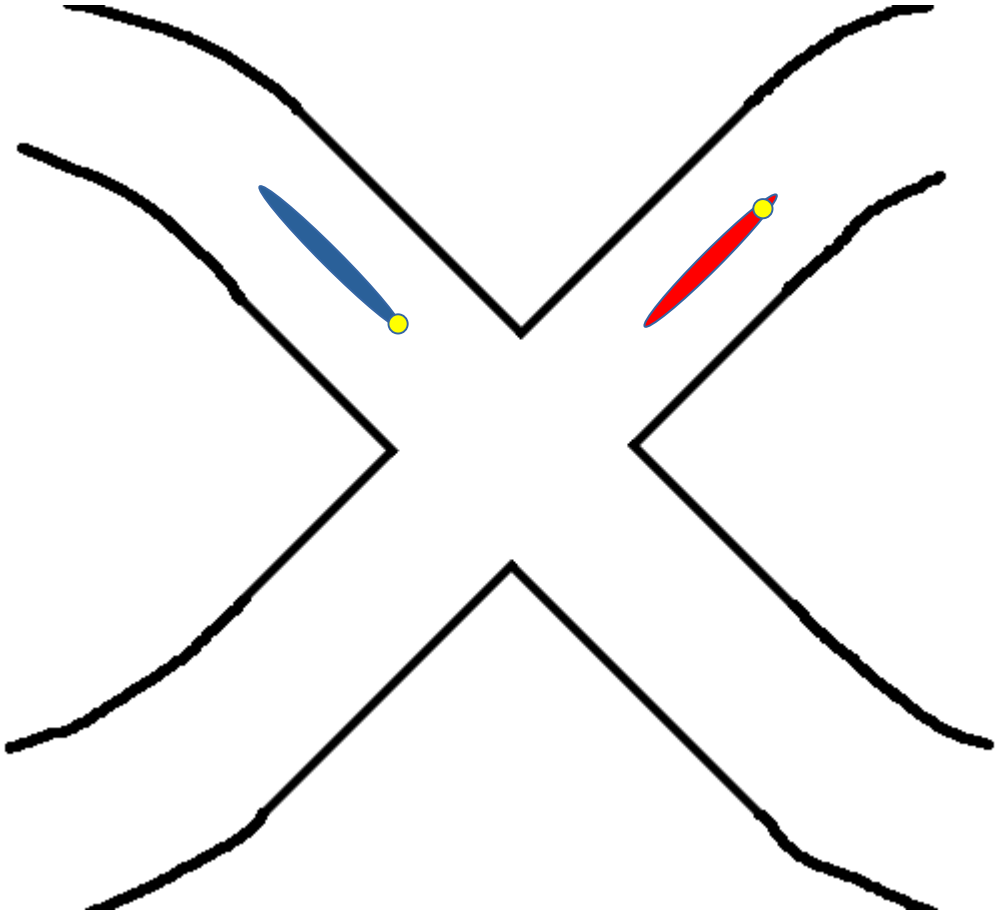
THANKS TO: FEDERICO CARRA, SIMON BARRIERE, ROMAIN NINET, ROMAIN GERARD, OSCAR SACRISSTAN DE FRUTOS, MICHAEL GUINCHARD, IGNACIO AVILES SANTILLANA, ADRIA GALLIFA TERRICABRAS, TEDDY CAPELLI, LUCIE BAUDIN, JORGE GUARDIA VALENZUELA, NIKOLINA VEJNOVIC, MARCO MASCI, LIVIA CARMEN COMAN, KEZIBAN KANDEMIR, VALENTINA CASADEI AND MANY MORE …

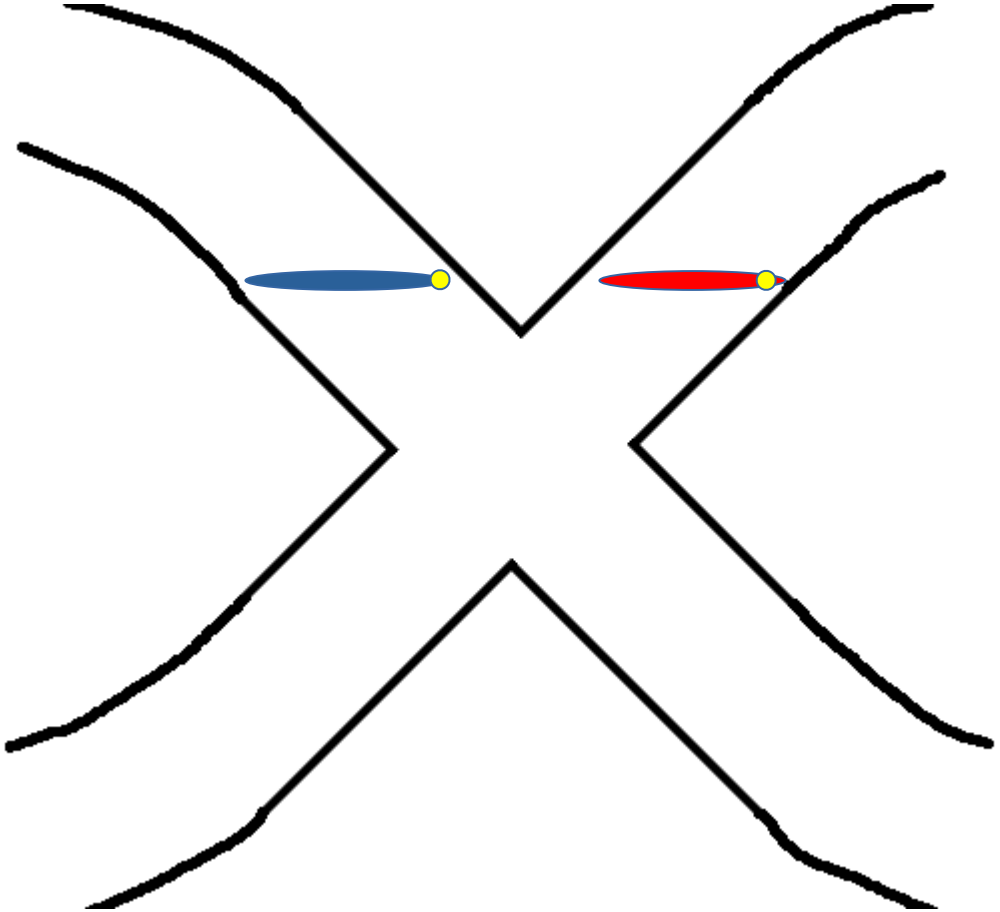
Collision at present



LHC

LHC

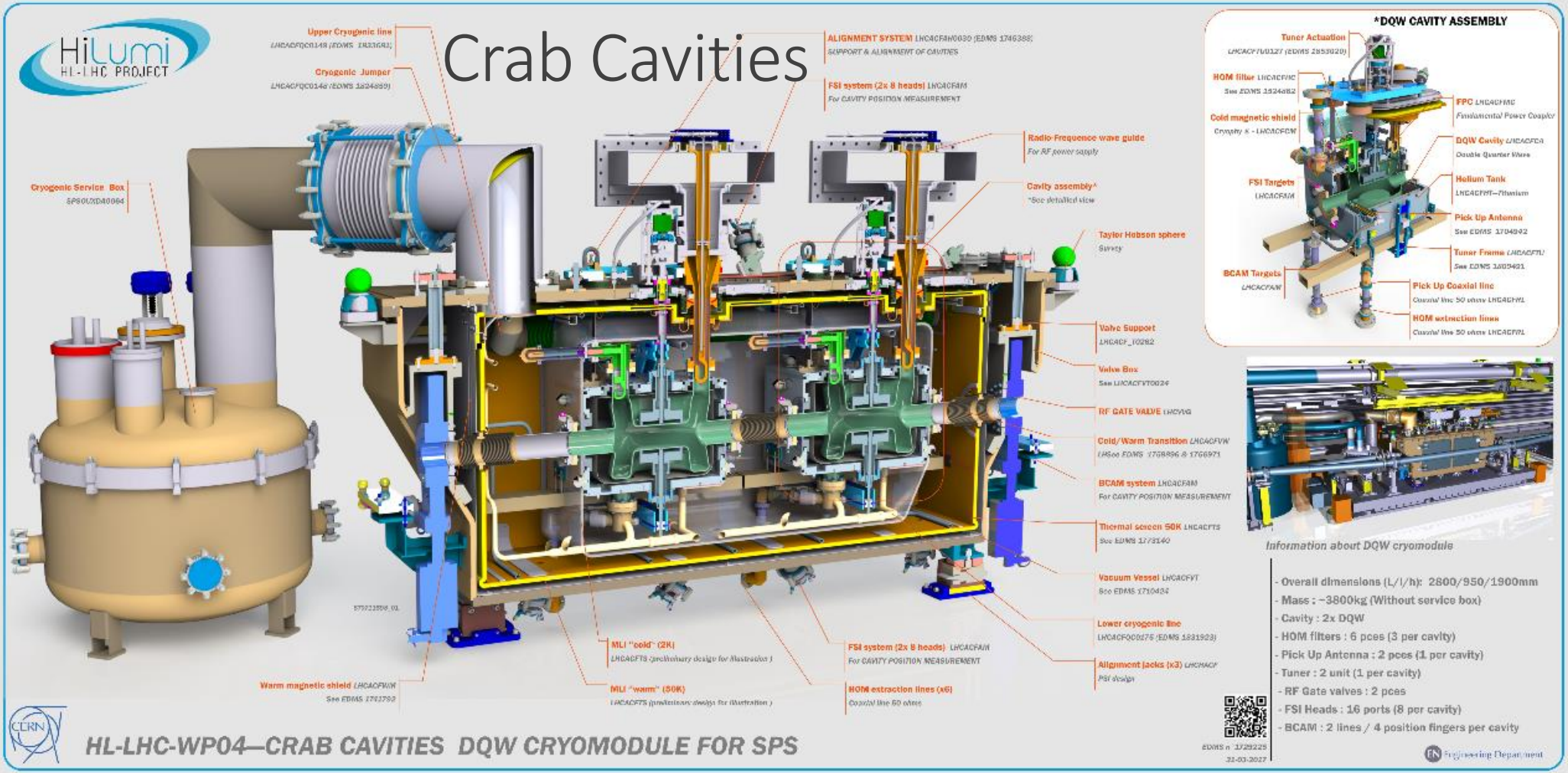
With Crab Cavities

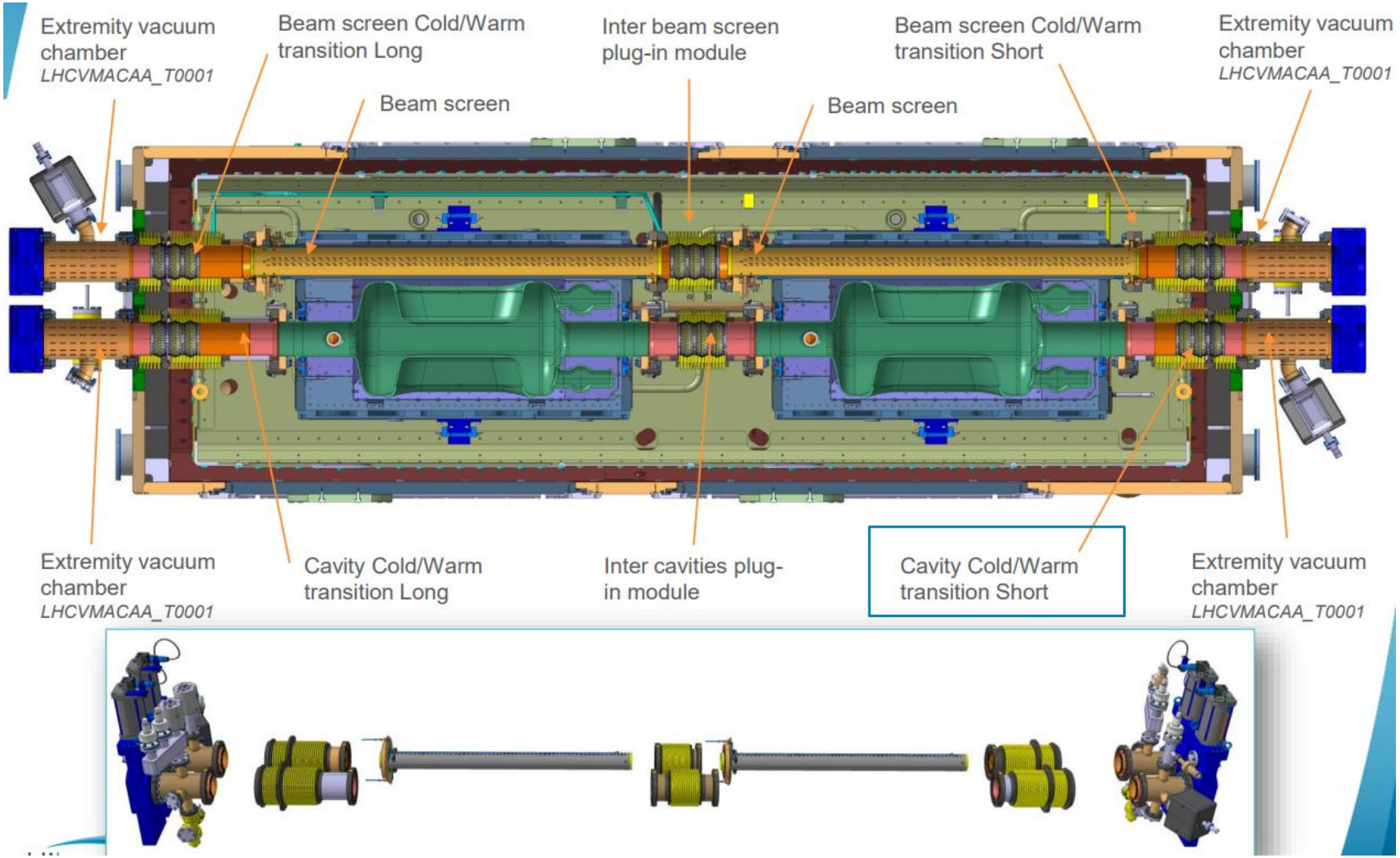


LHC

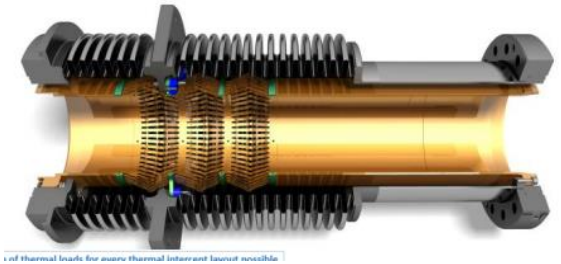
LHC

Crab Cavities

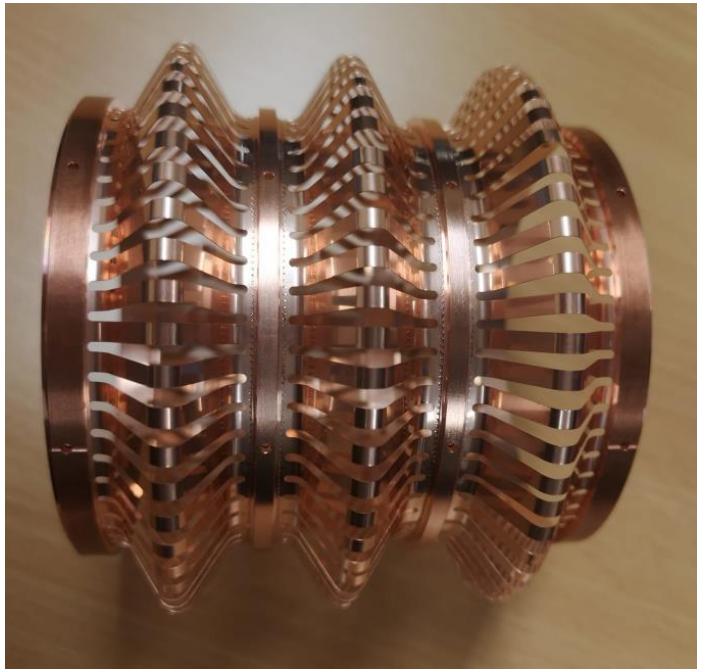



Extremity vacuum chamber
LHCVMACAA_T0001
Beam screen Cold/Warm transition Long
Beam screen
Inter beam screen plug-in module
Beam screen
Beam screen Cold/Warm transition Short
Extremity vacuum chamber
LHCVMACAA_T0001
Extremity vacuum chamber
LHCVMACAA_T0001
Cavity Cold/Warm transition Long
Inter cavities plug-in module
Cavity Cold/Warm transition Short
Extremity vacuum chamber
LHCVMACAA_T0001

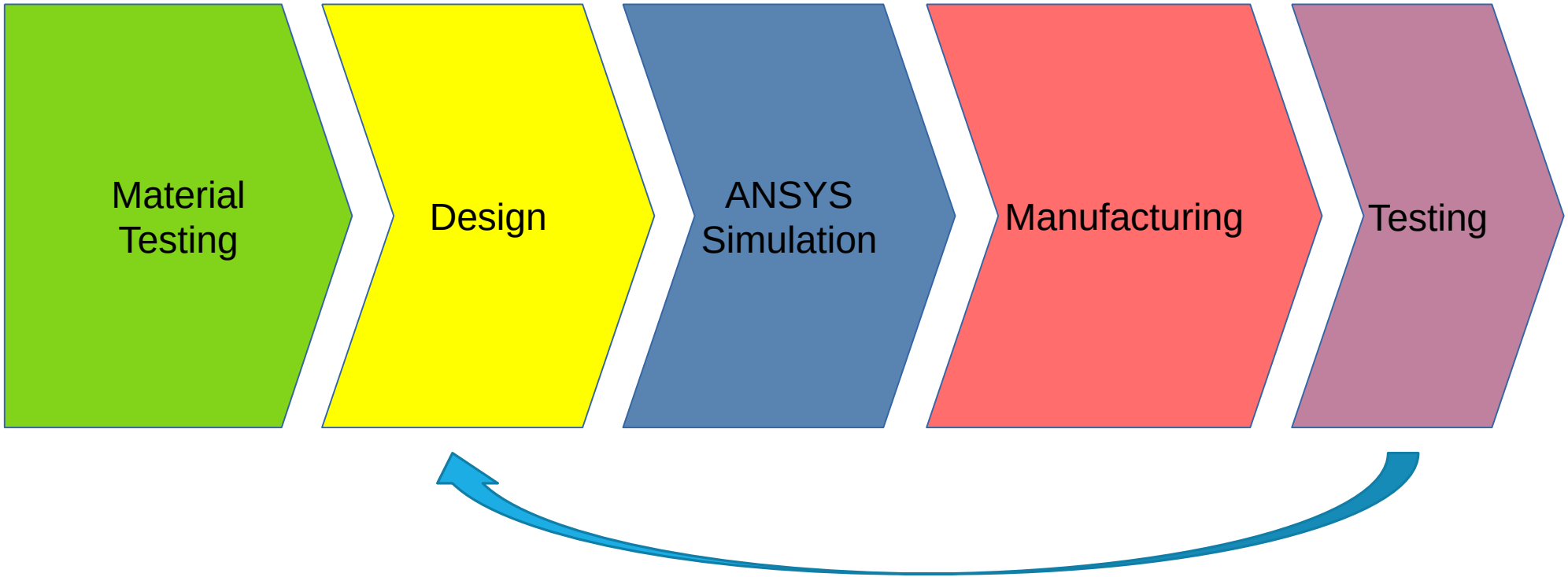
The RF fingers



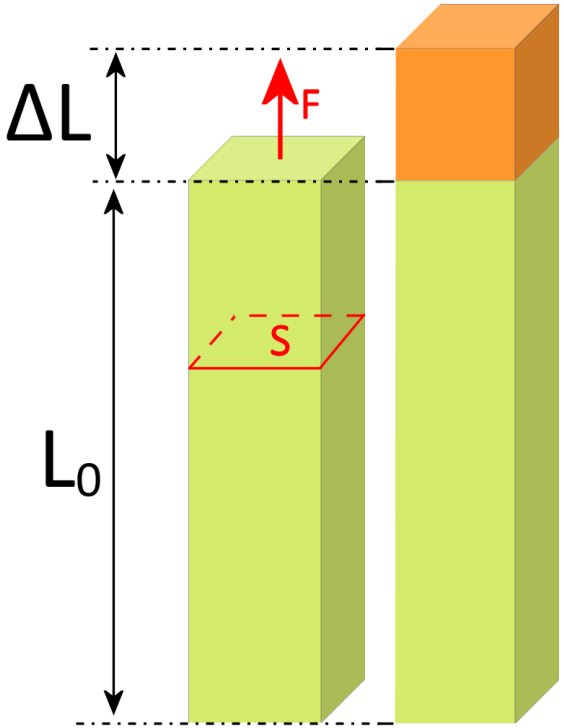
- Link components which vary in length due to the change in temperature
- Maintain electrical contact between the two components
- They are made of Copper Beryllium



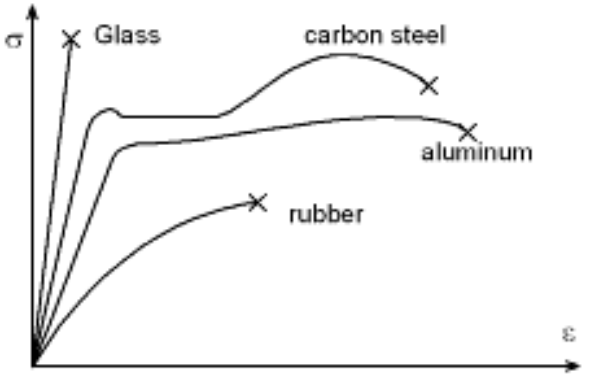
The life cycle of a component



Mechanical properties of a material



- Stress: $\sigma = \frac{F}{S}$
- Strain: $\varepsilon = \frac{\Delta L}{L_0}$

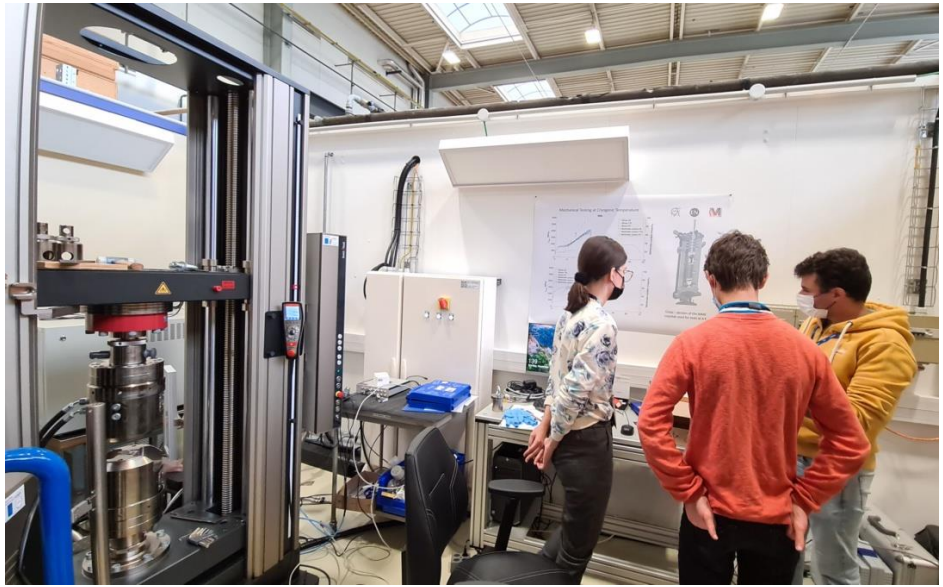


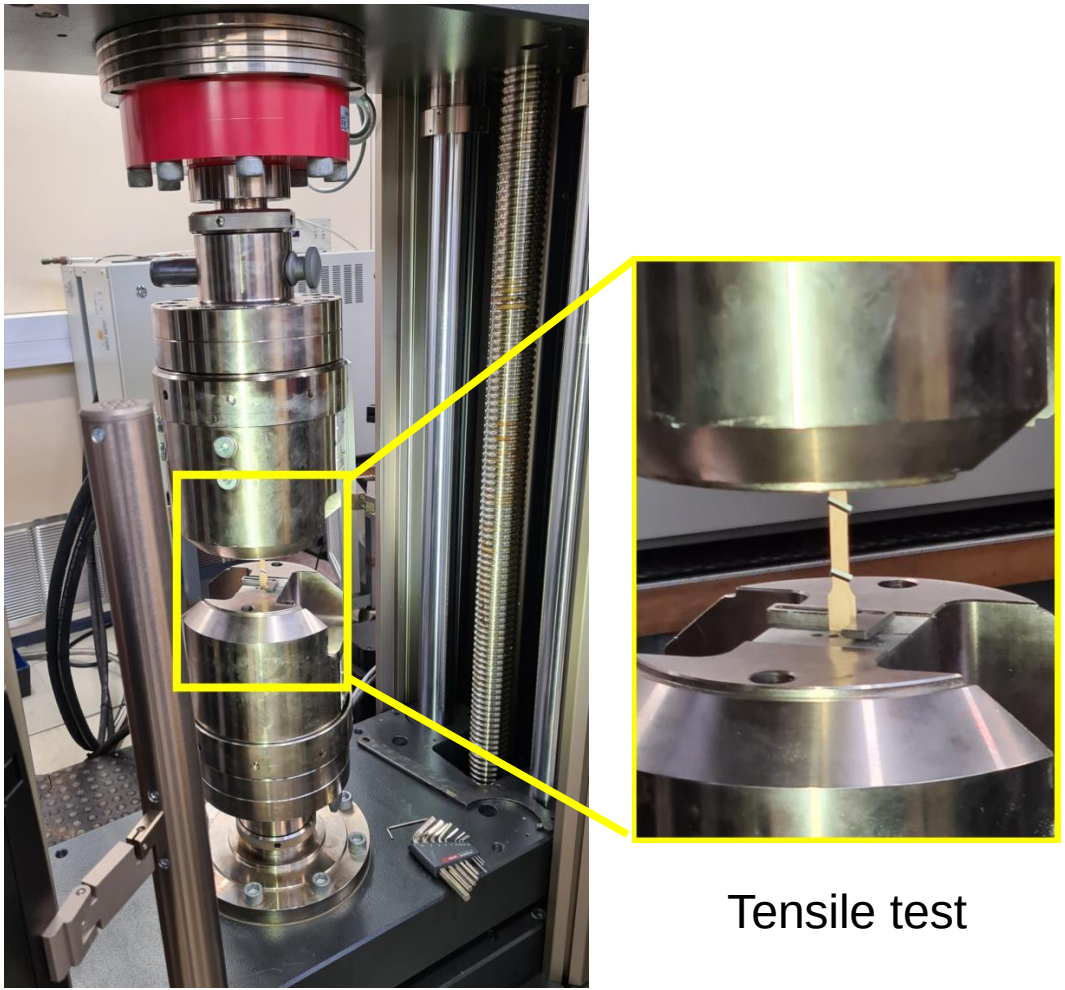
Hooke's Law:

$$\sigma = E\varepsilon$$

Determining the mechanical properties of Copper Beryllium

In order to perform such an experiment, specimens made of the material which we are interested in are fixed onto the machine, which will pull the specimen until it breaks.

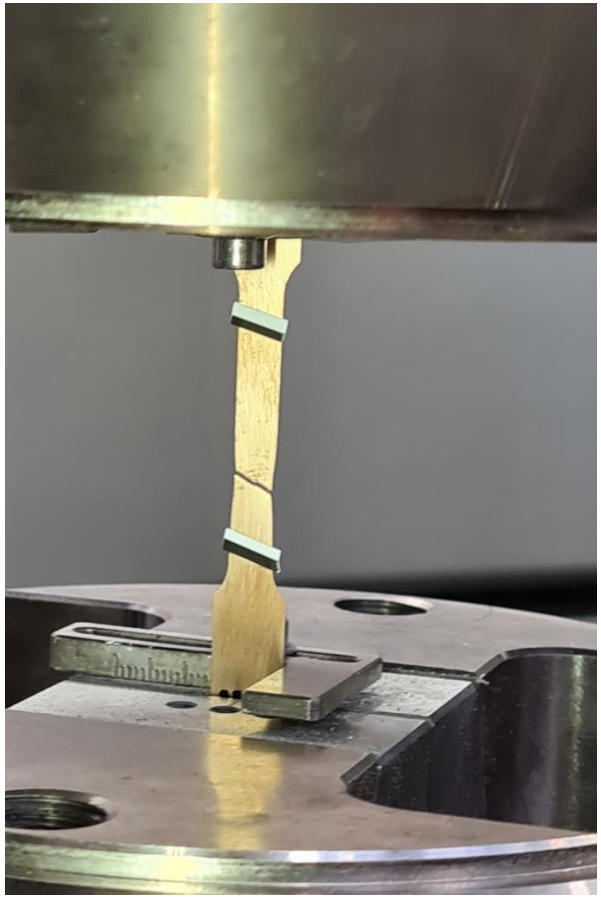




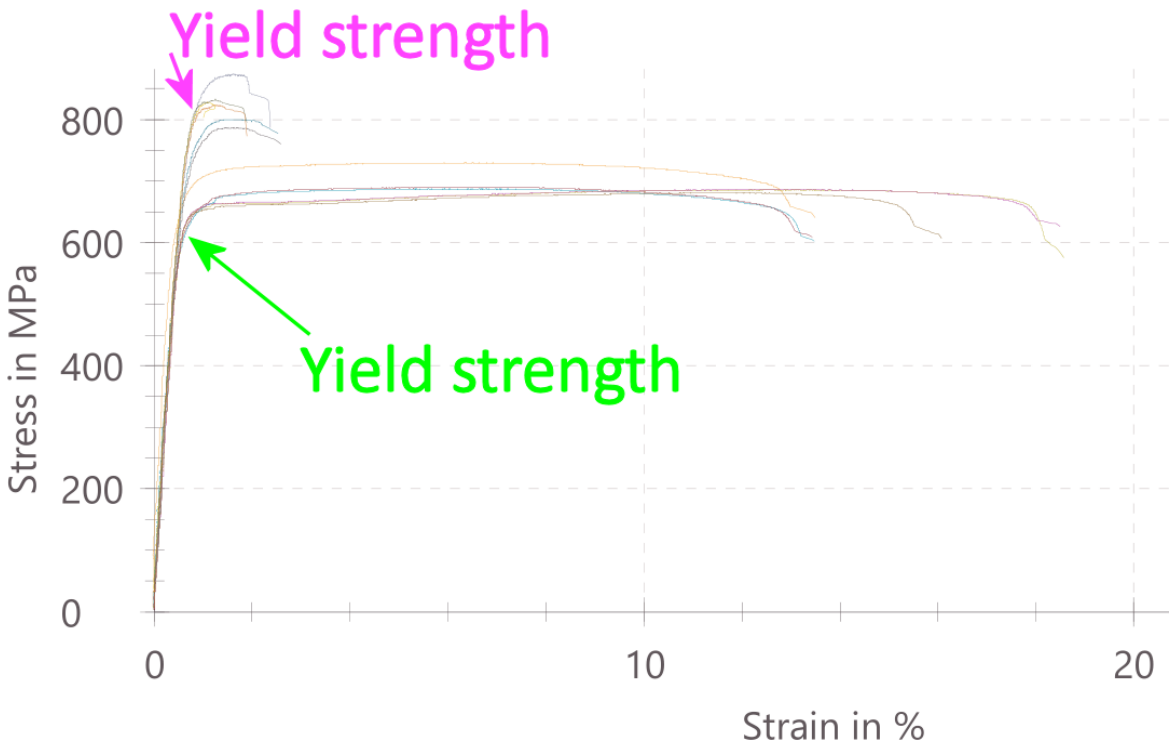
Tensile test

Observing the behaviour of the component

After the tensile test

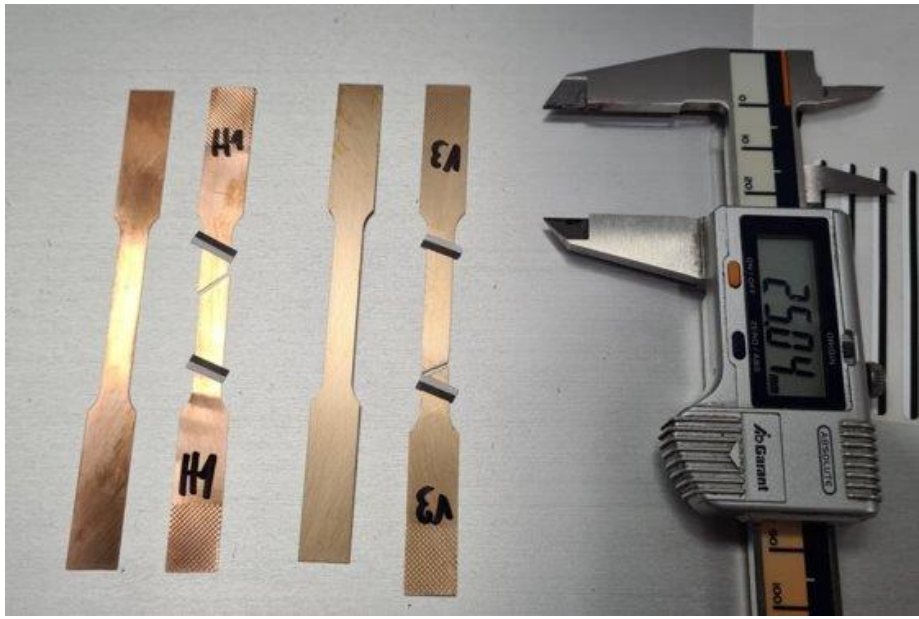


Results: stress-strain curve

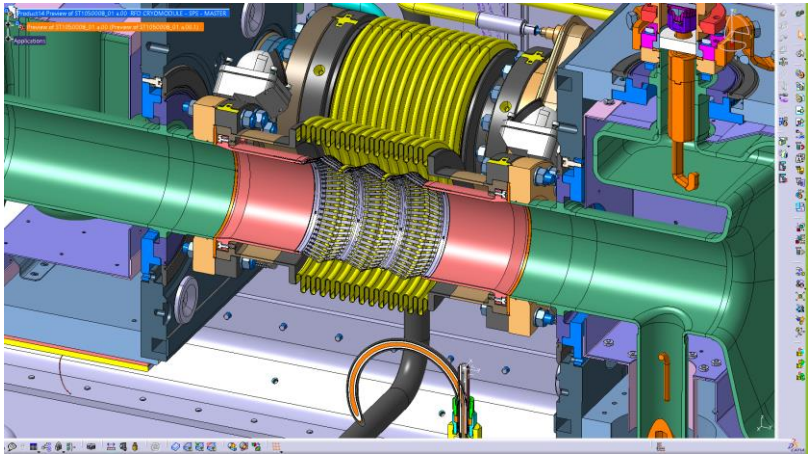


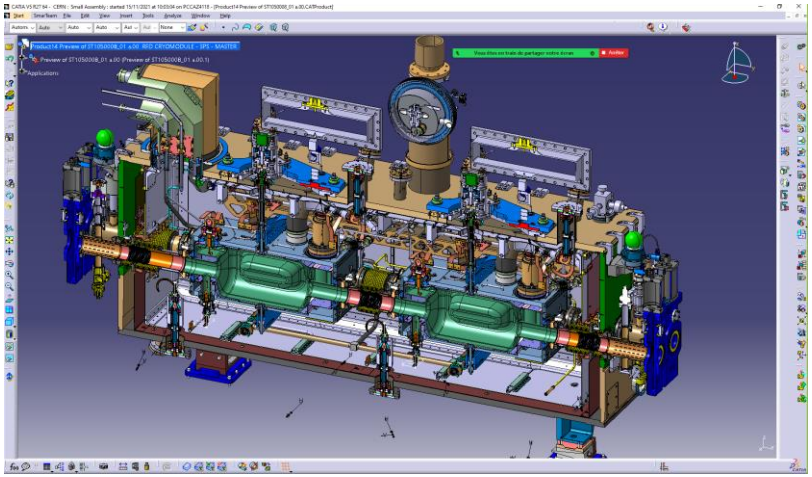
The initial slope is Young's modulus of elasticity (E)

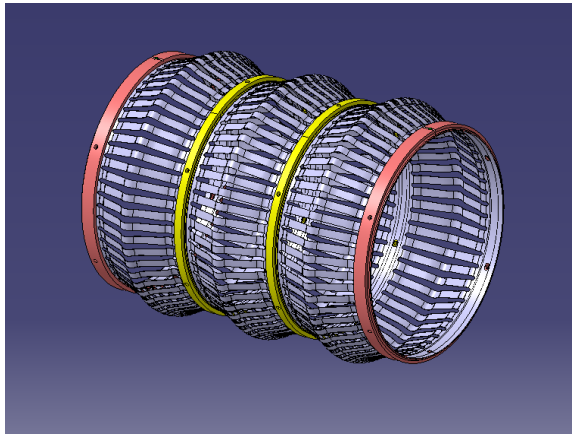
The yield strengths are different due to the fact that we used two types of alloys: the first one had more beryllium in its composition than the second one.
The second one elongated more before fracture.

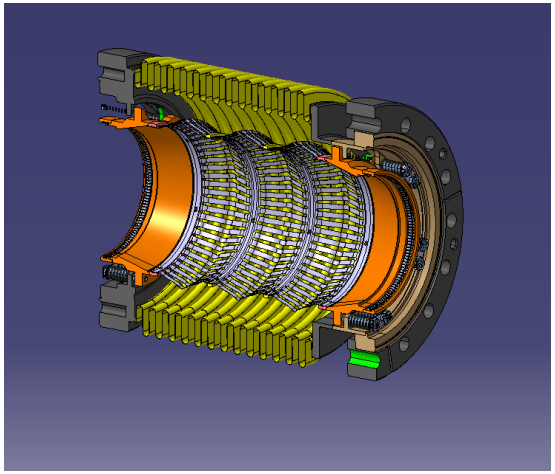


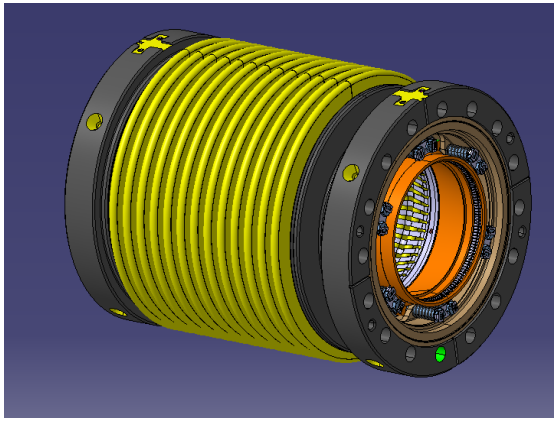
Design - the main assembly done in CATIA





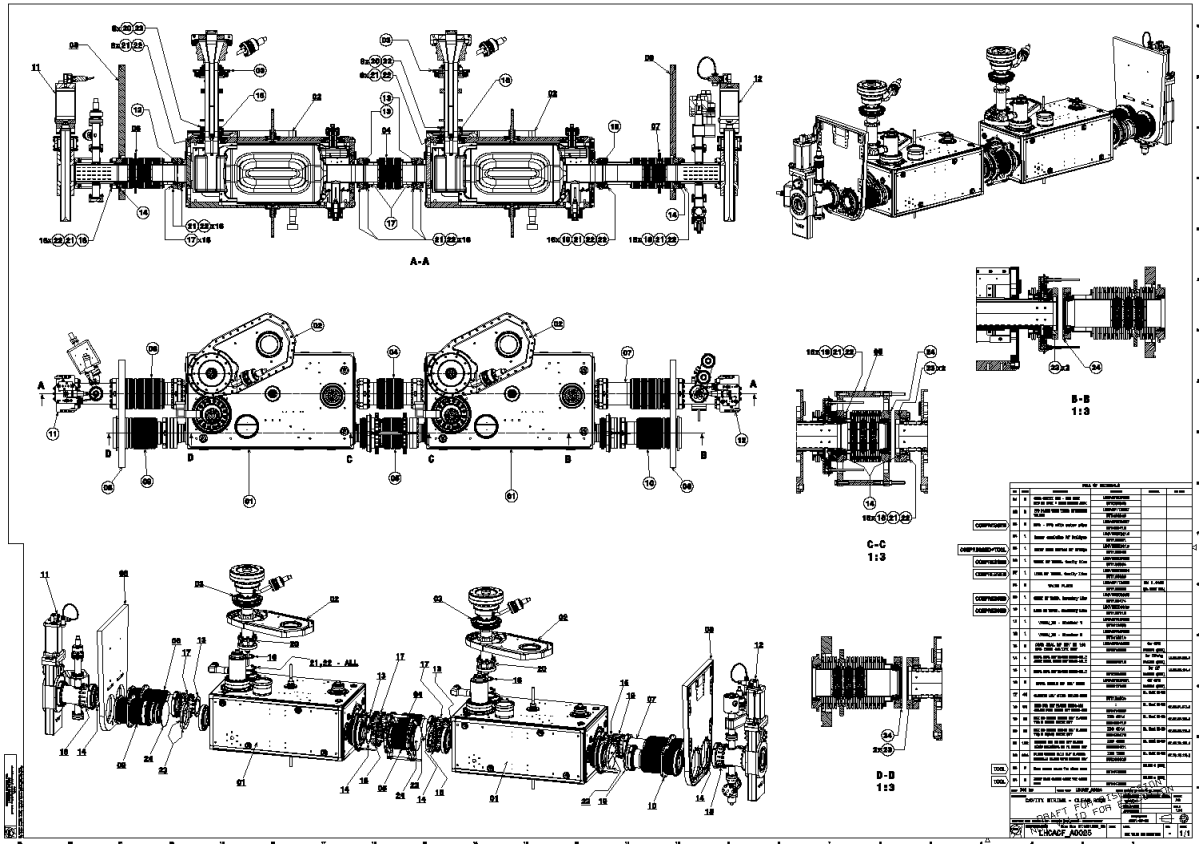


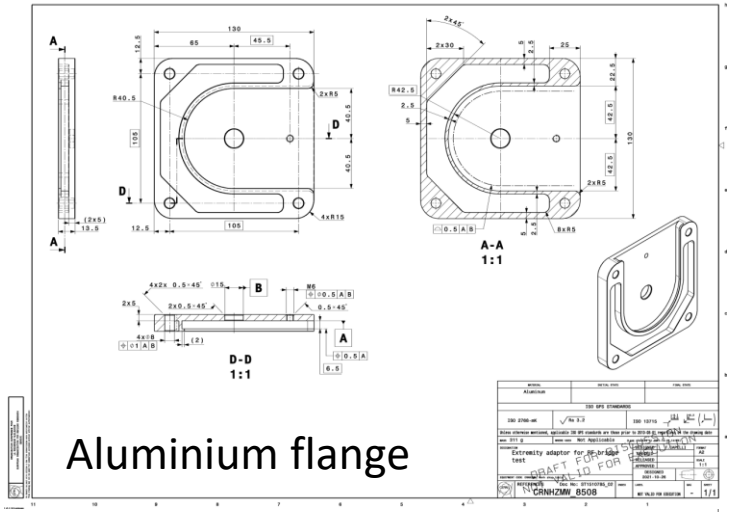




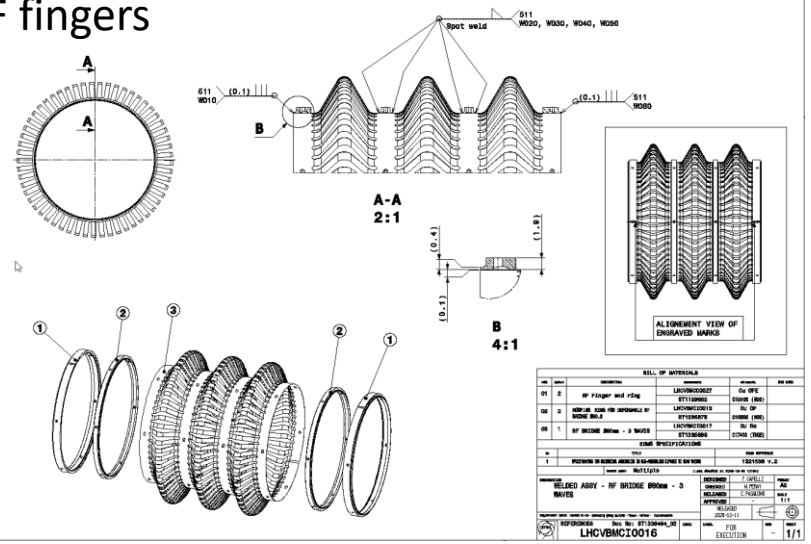
Technical drawings

Crab cavities assembly procedure

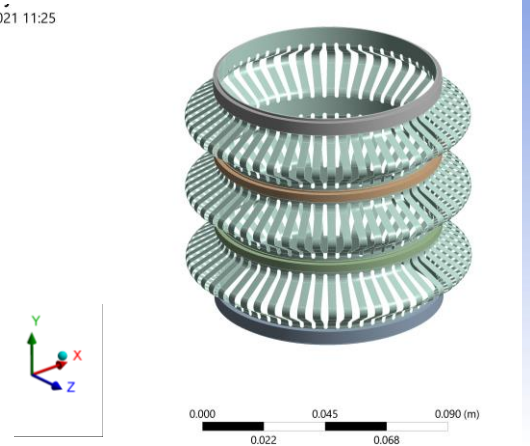


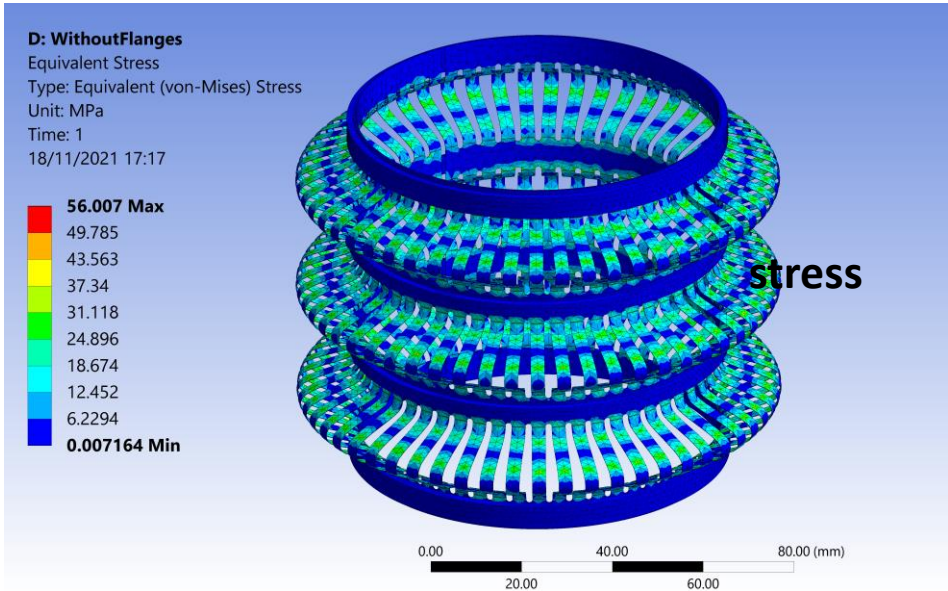


RF fingers

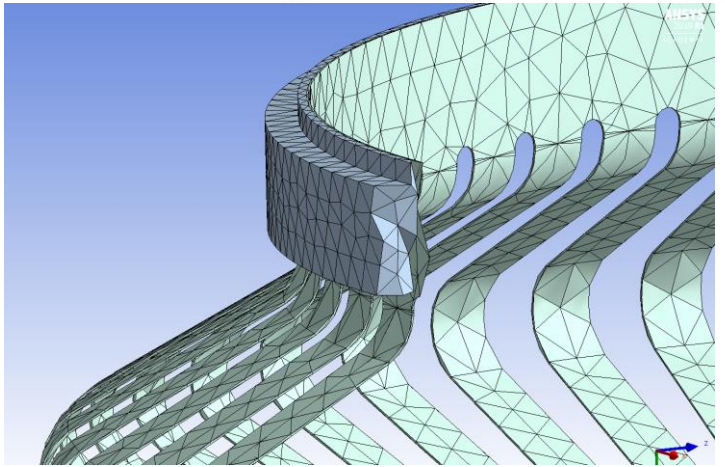


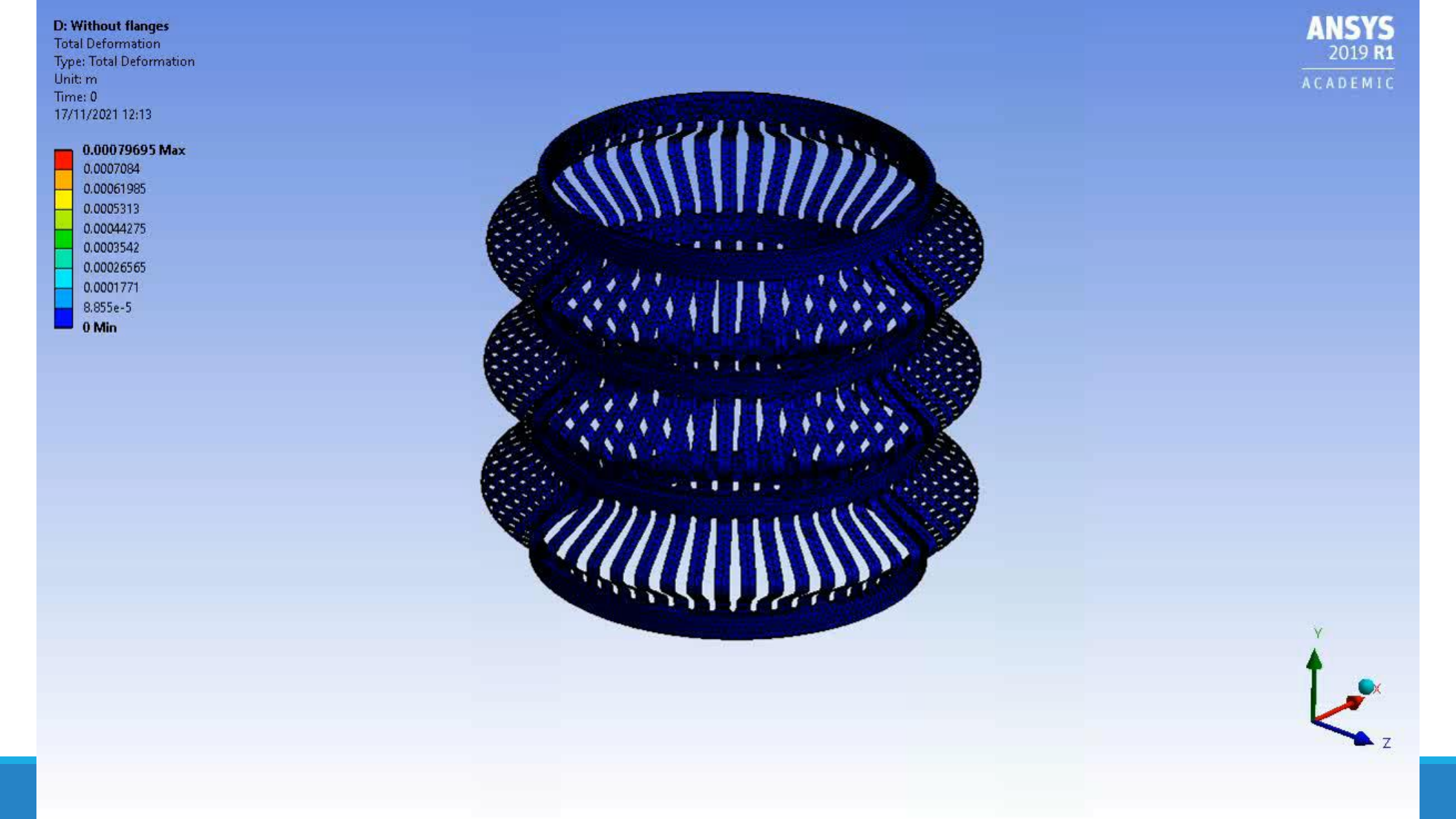
Simulations in ANSYS





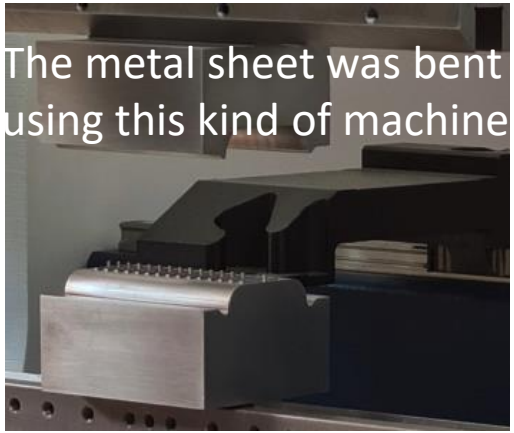
- Based on Finite Element Methods theory (FEM)
- Using SpaceClaim to simplify the geometry of the object
- Using ANSYS to add the material data obtained in the mechanical test (yield strength etc.)
- Generating a mesh
- Adding boundary conditions
- Applying a force of 10 N on the Y axis to simulate the compression test

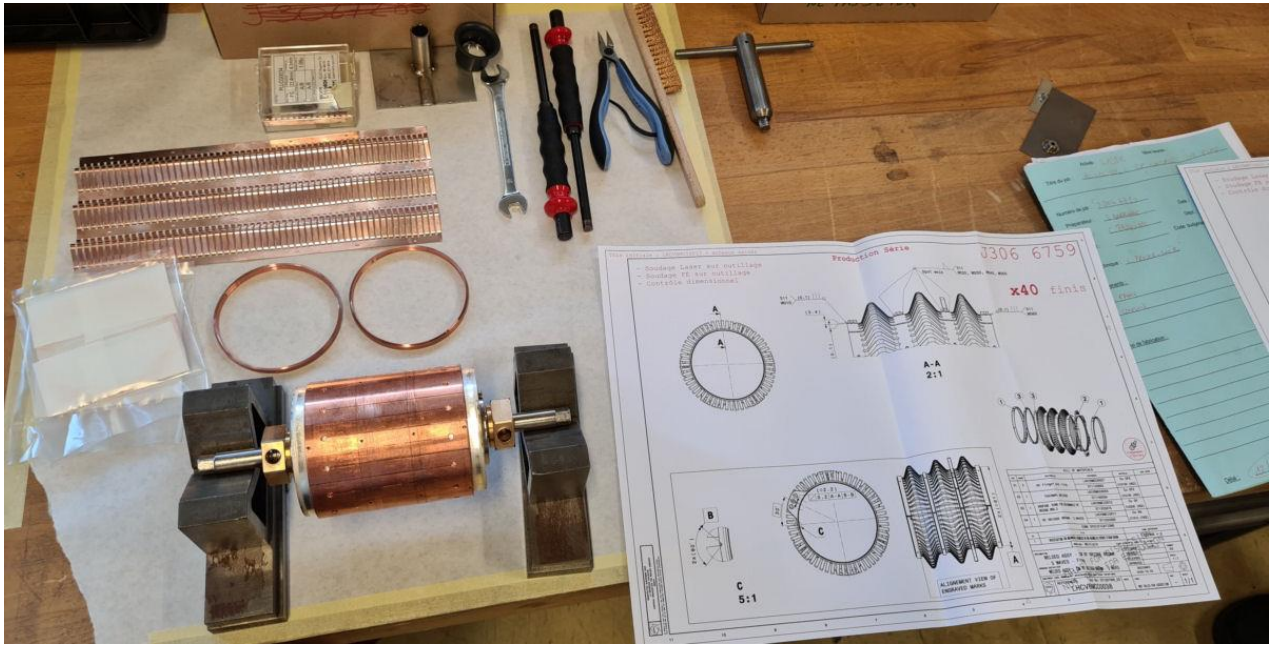



D: Without flanges
Total Deformation
Type: Total Deformation
Unit: m
Time: 0
17/11/2021 12:13
0.00079695 Max
0.0007084
0.00061985
0.0005313
0.00044275
0.0003542
0.00026565
0.0001771
8.855e-5
0 Min
ANSYS
2019 R1
ACADEMIC
Y
X
Z

Manufacturing

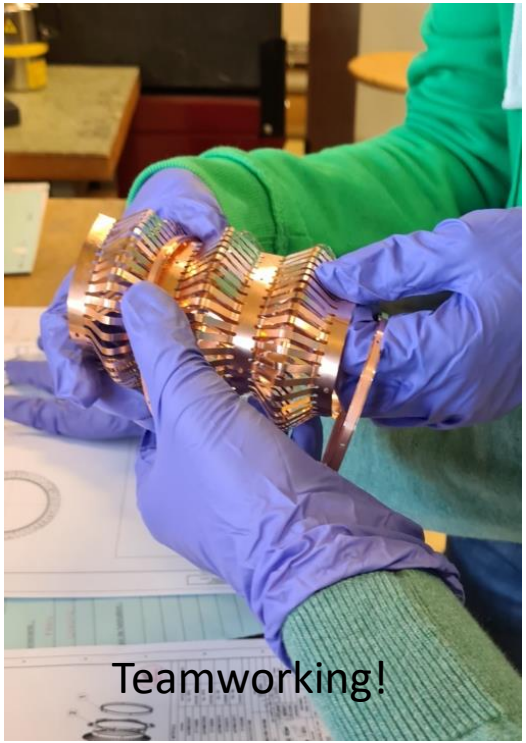
All the necessary parts & tools:



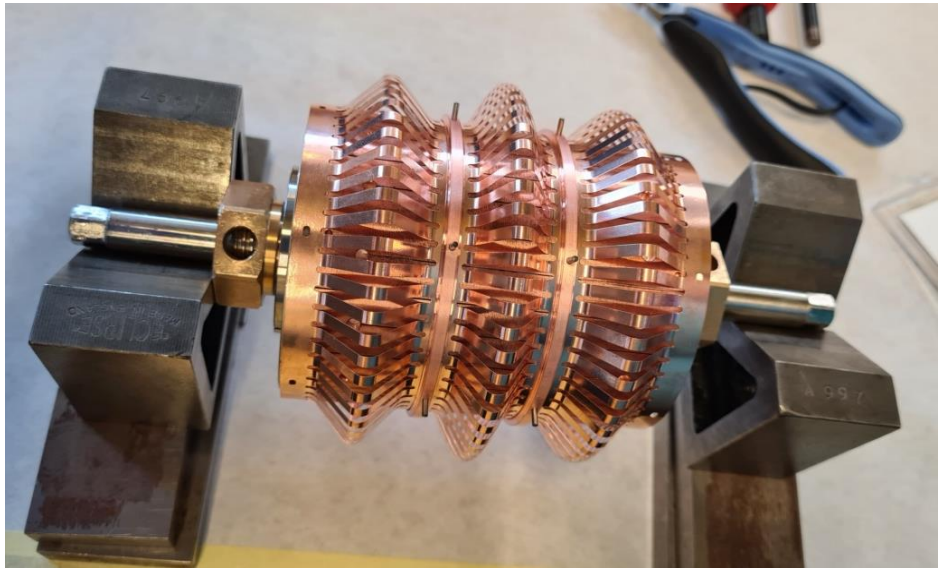


Assembly

Putting the parts together

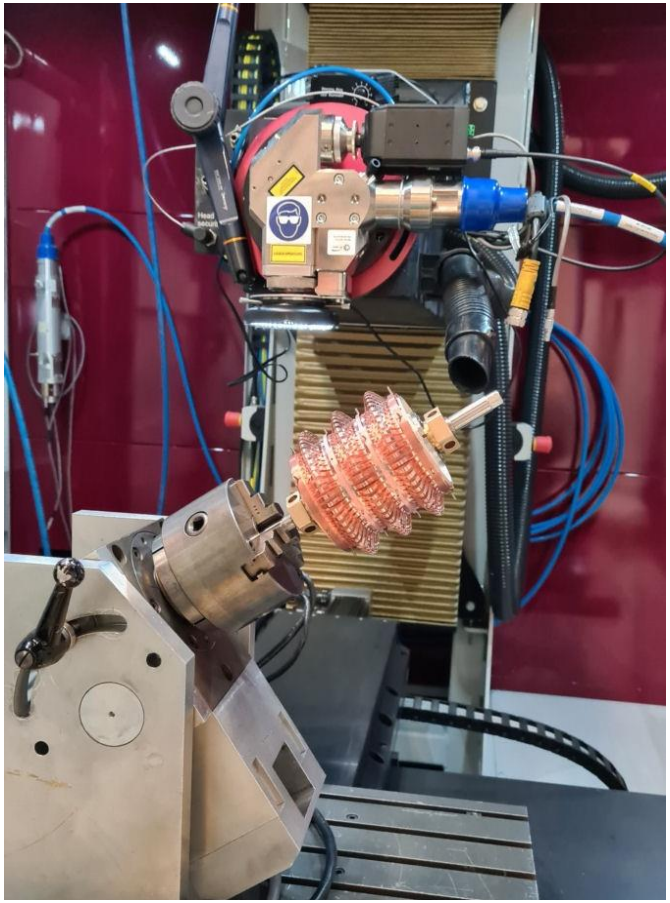


Teamworking!

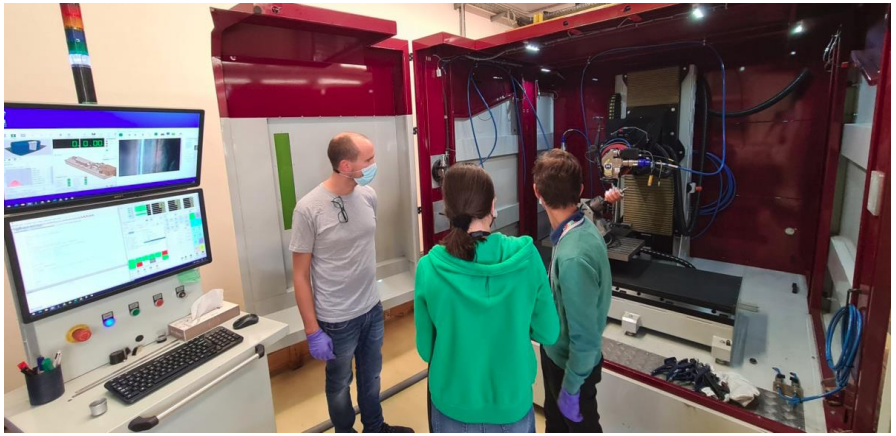


After bending, the rings must be welded onto the sheet.
For the welding process, the component was put on a support.

Machining technique: Laser Welding

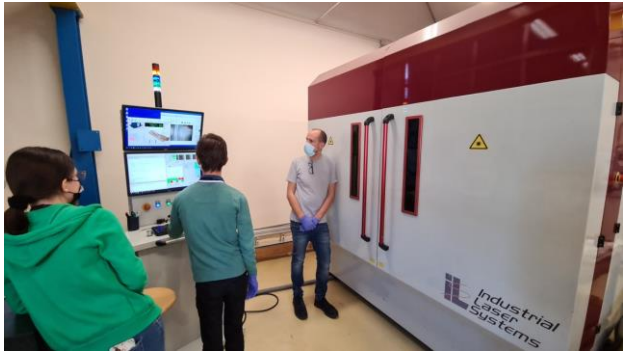


Fixing the component into the welding machine

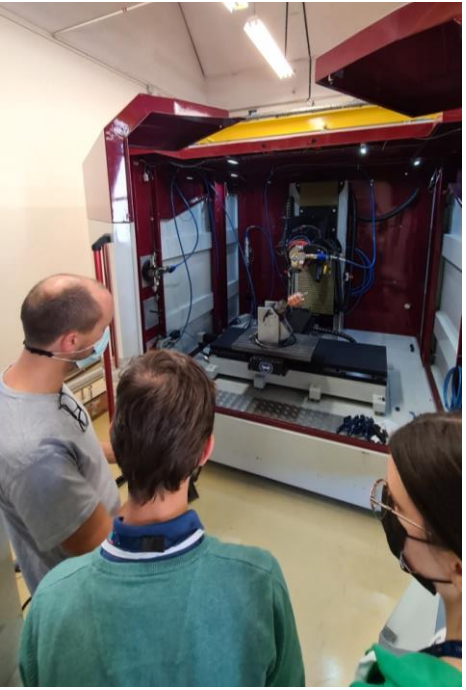


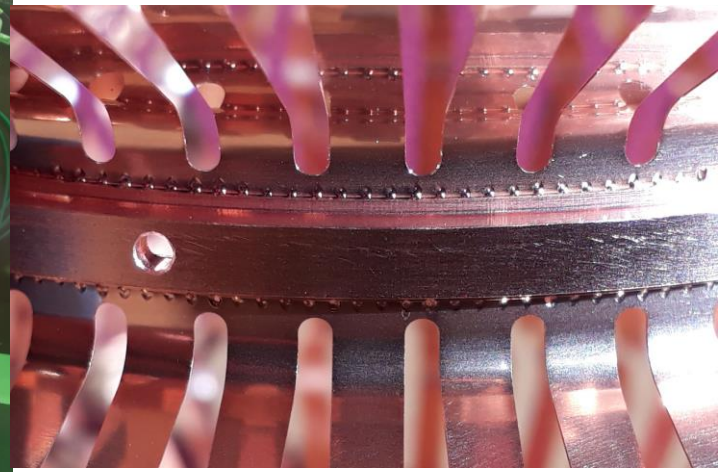
A quick check before pressing the big green button

… and setting the parameters on the computer



Through the window...





What a nice weld!

Machining technique: Milling

We used milling (the tool is moving and the object is static) to manufacture two flanges, which we connected to the lower and upper parts of the RF fingers in case we wanted to use them later, in the compression test.

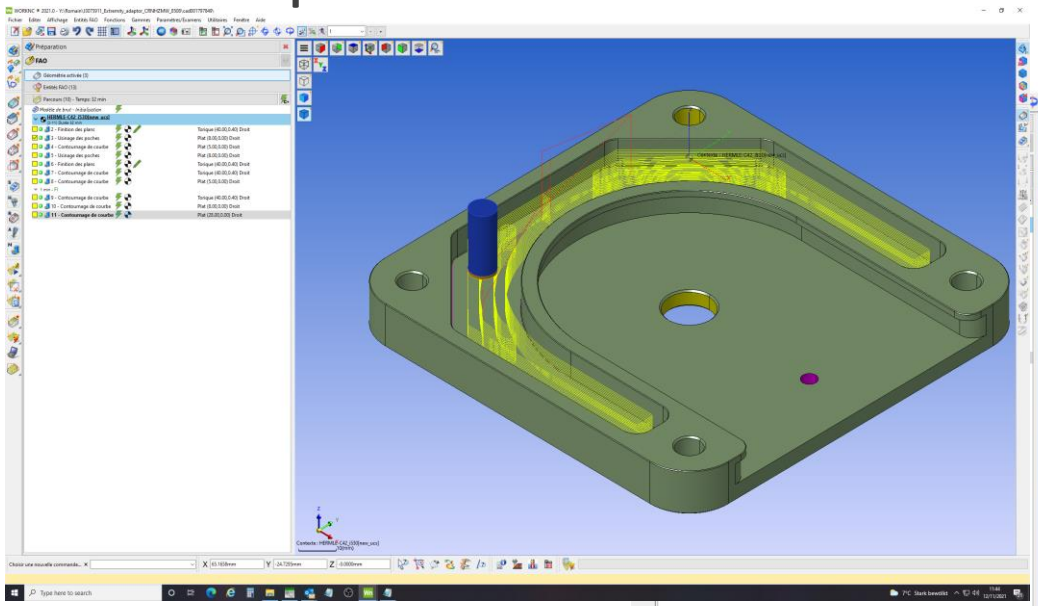
The milling machine

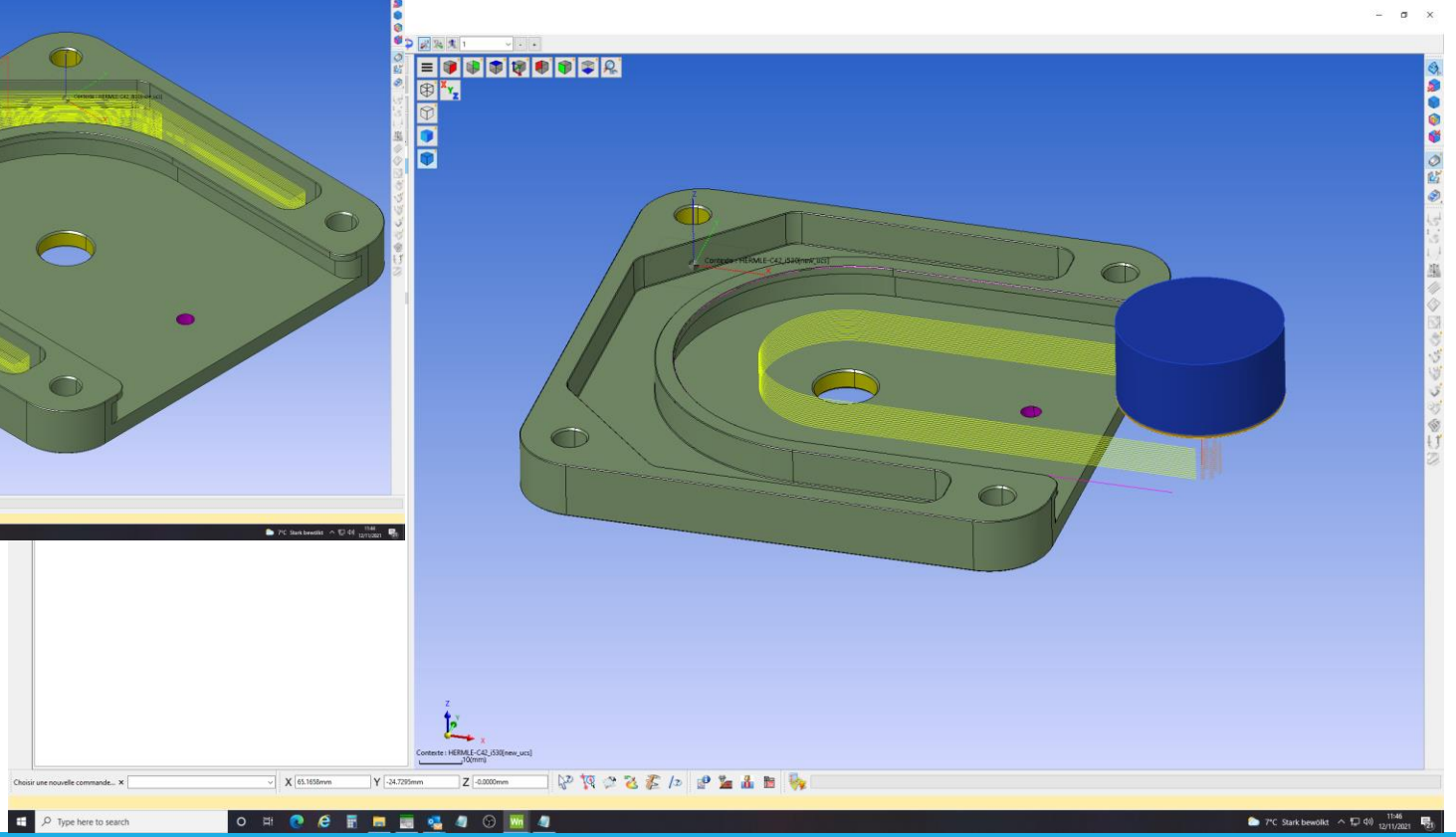
Measuring the block of material

The initial piece of Aluminium

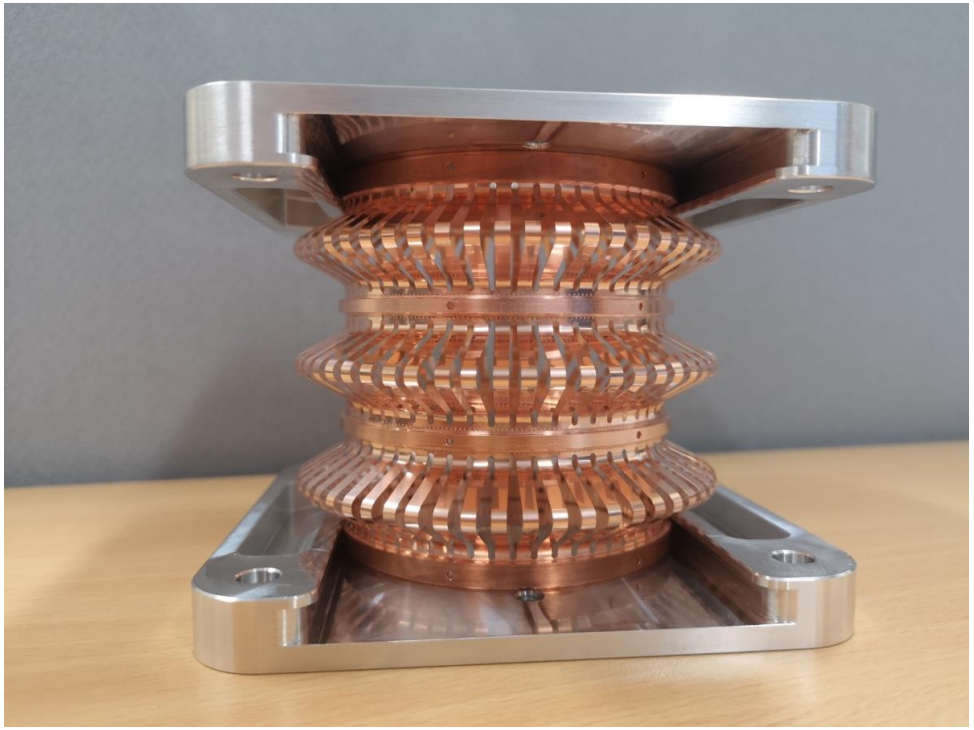
Calibrating the piece

Programming the milling pattern on the computer



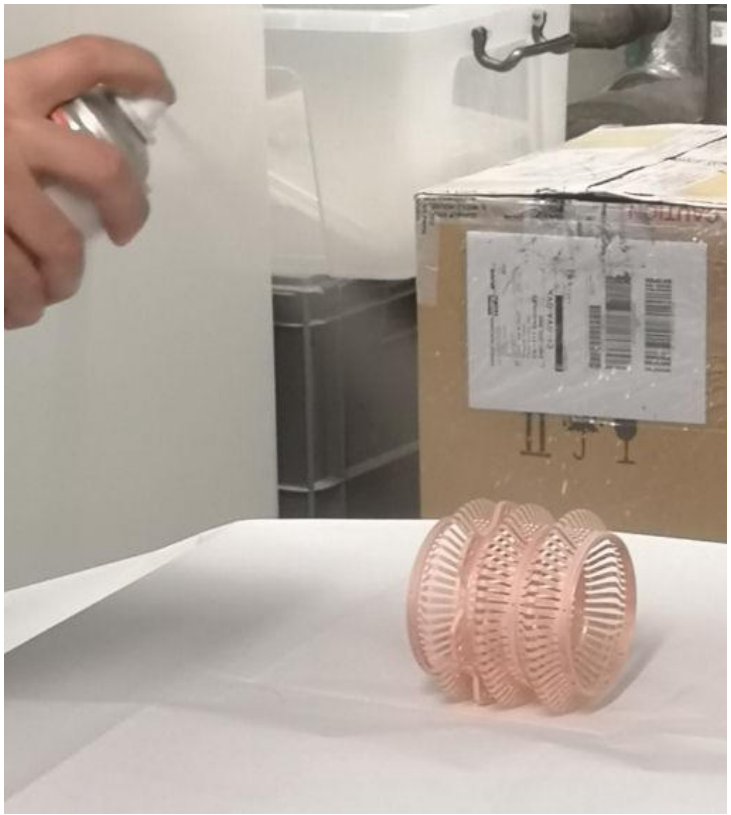


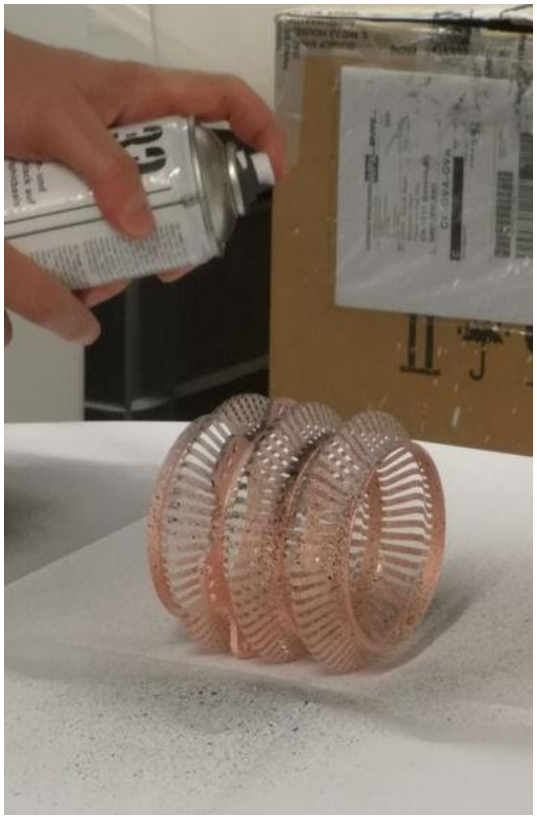
After milling



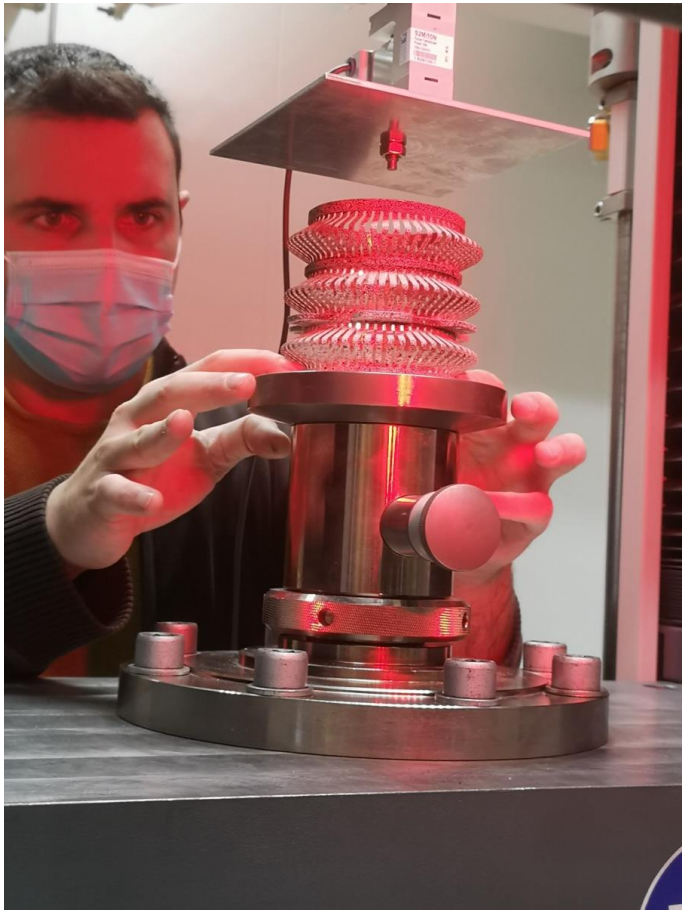
Testing the component

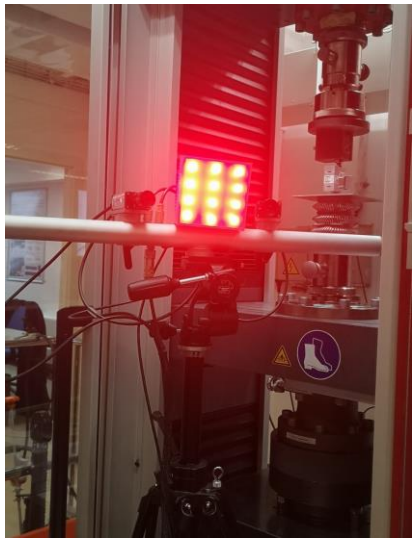
- The component's behaviour was simulated on the computer, but now it's time to test its real behaviour!
- The RF fingers were sprayed with a white substance (talc) and then with a black substance (graphite powder) to create a high contrast dotted surface.

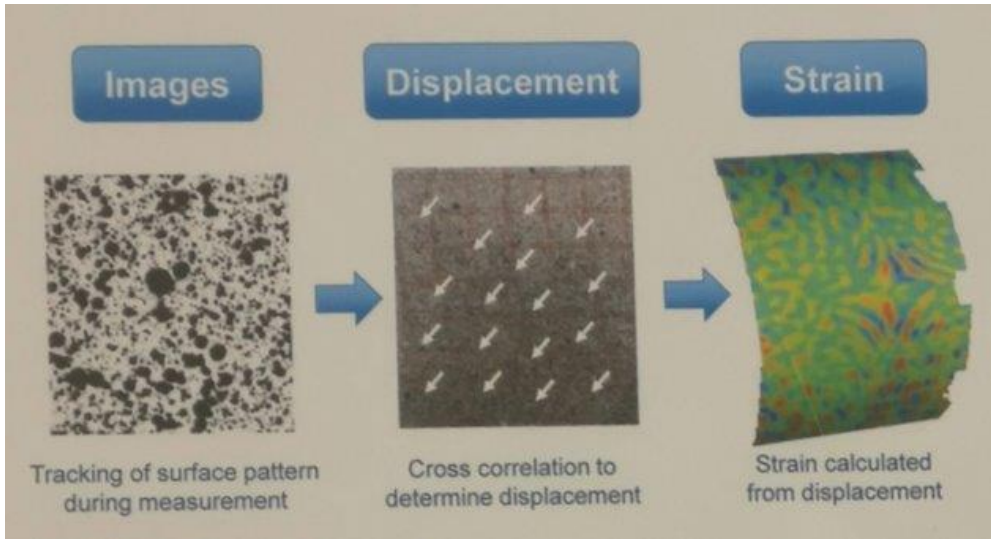


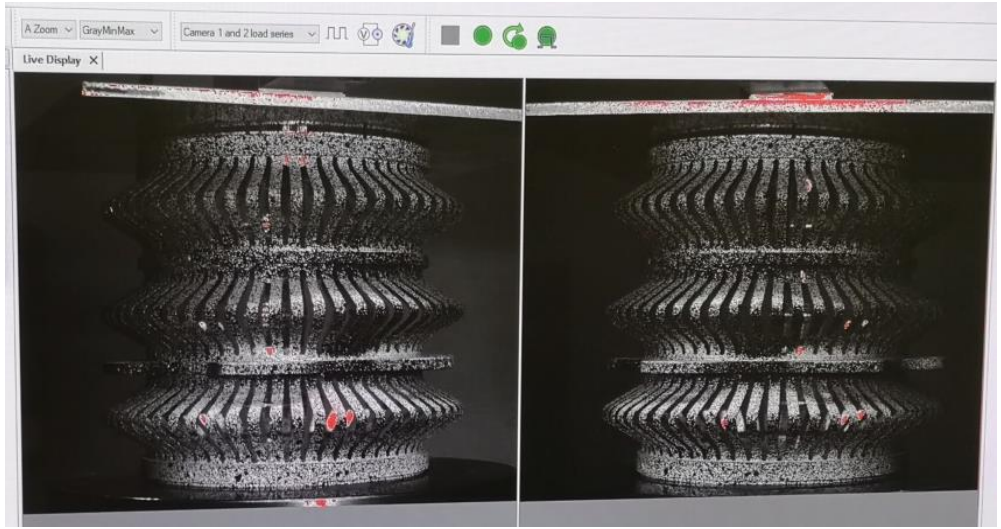


Fixing the component into the machine



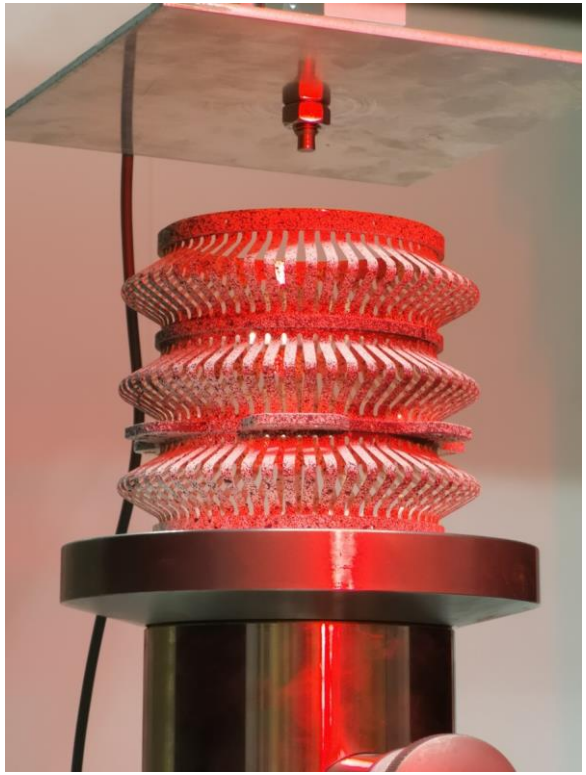




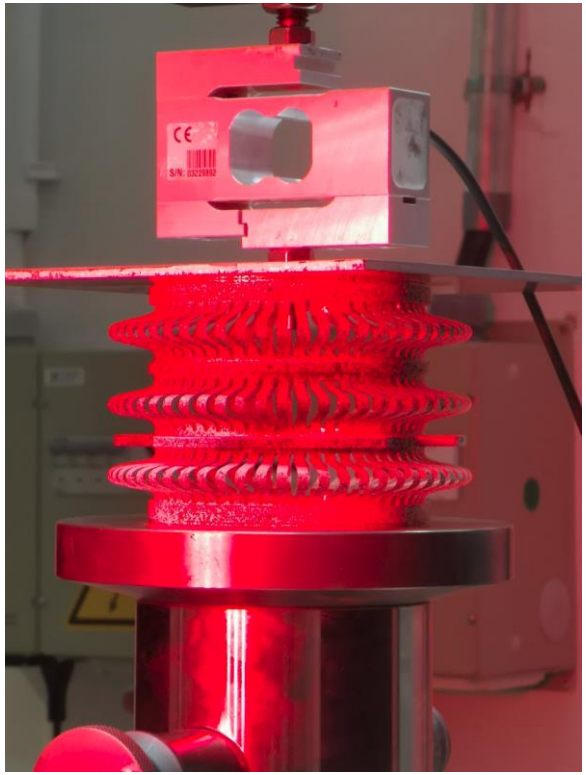


Digital Image Correlation (DIC)

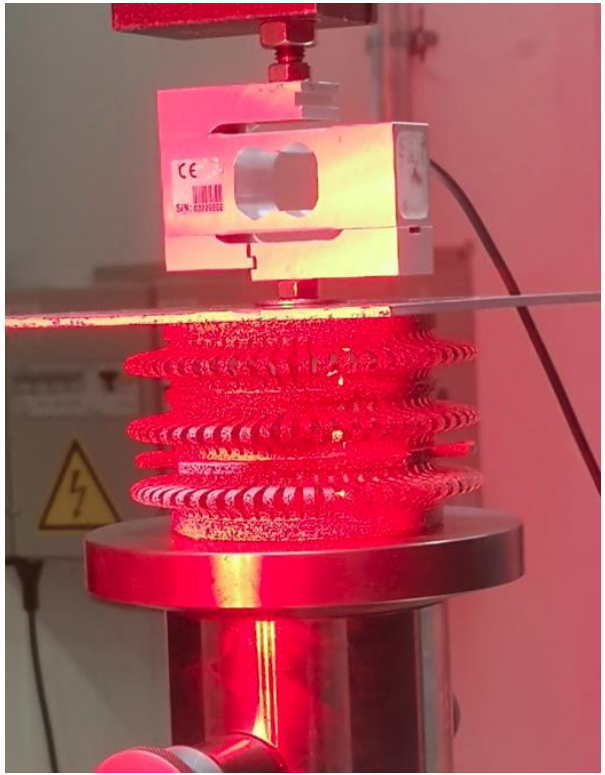
Testing the component through compression



0 N

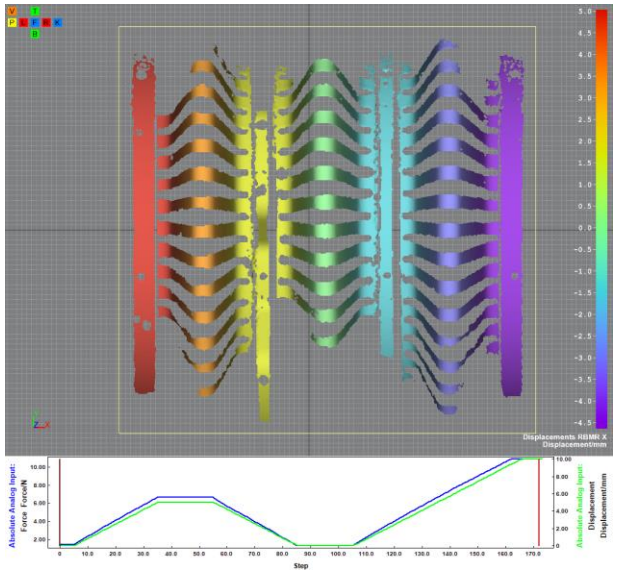


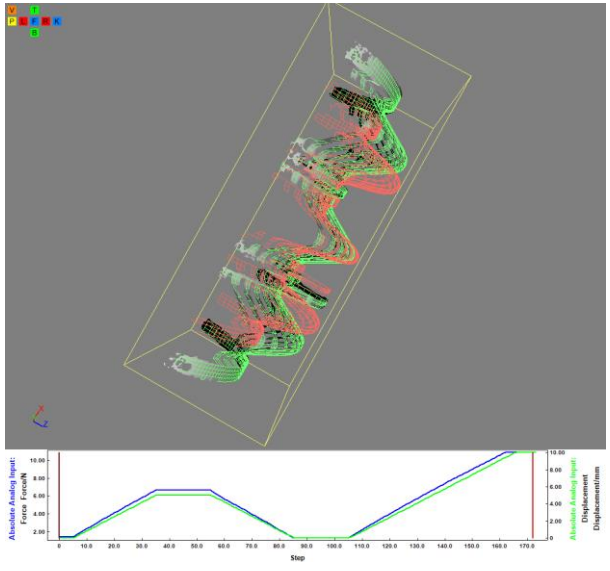
10 N

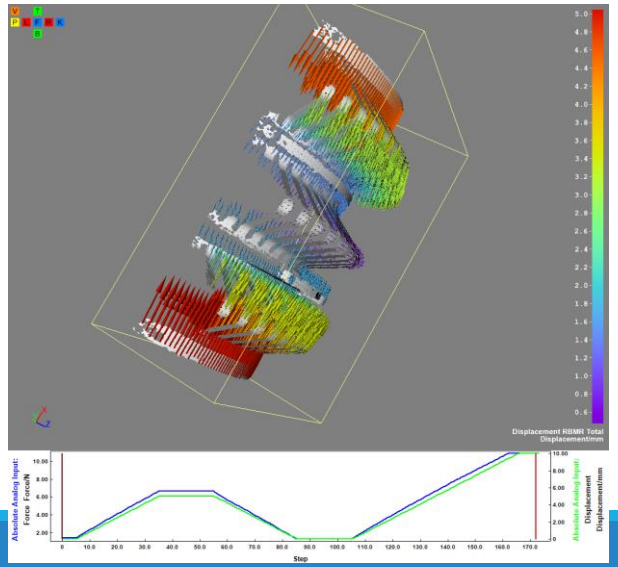


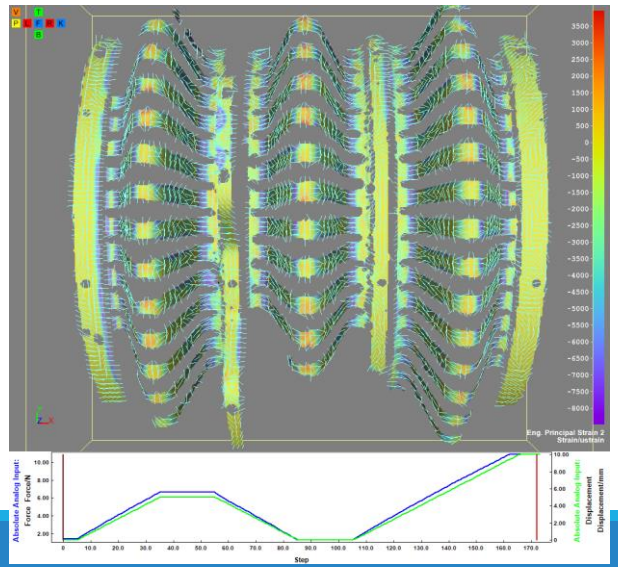
20 N

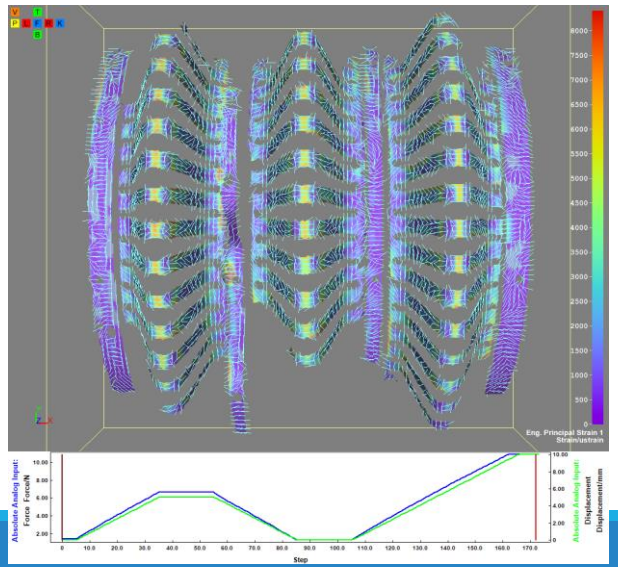
Displacement obtained from DIC



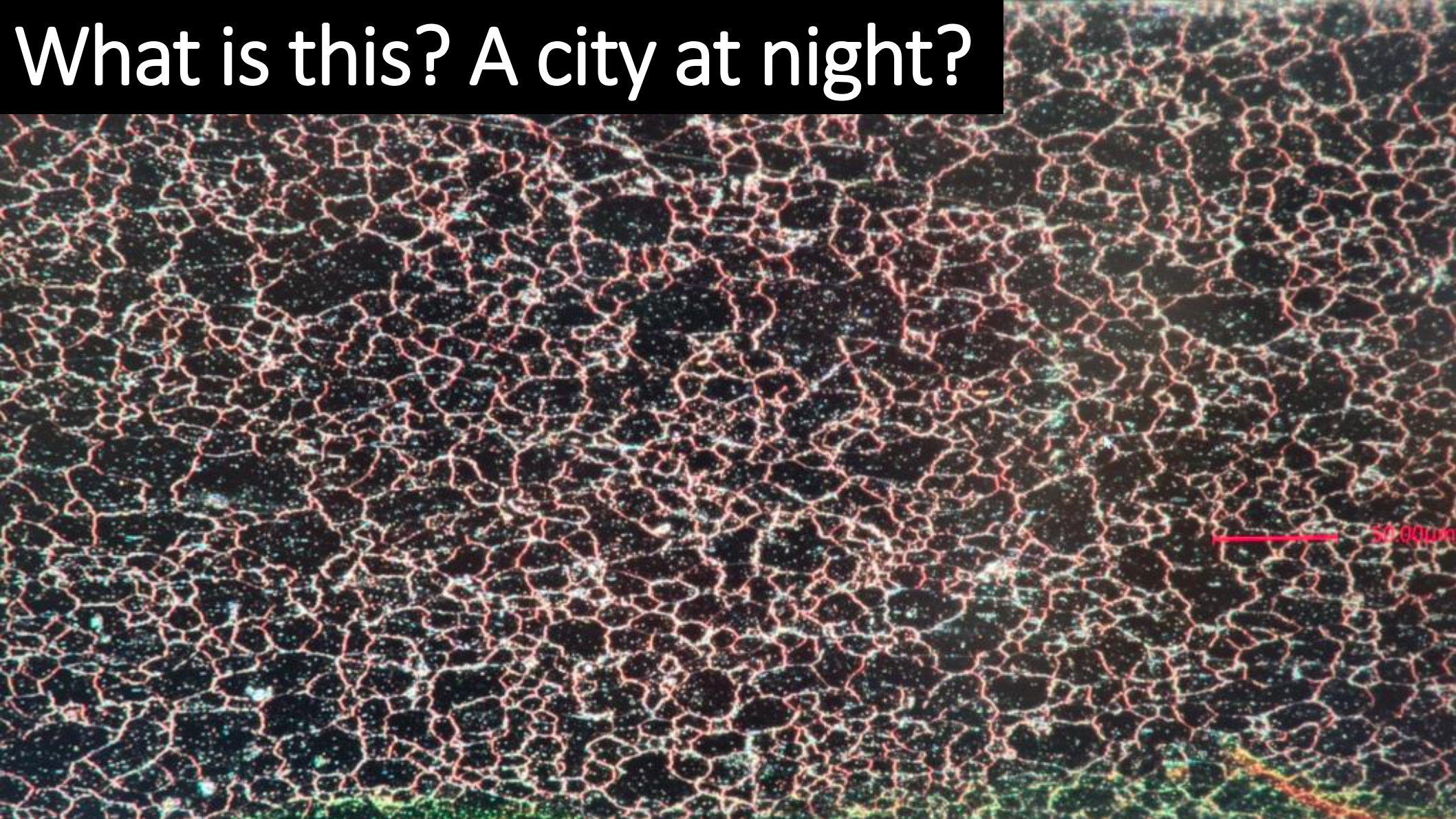




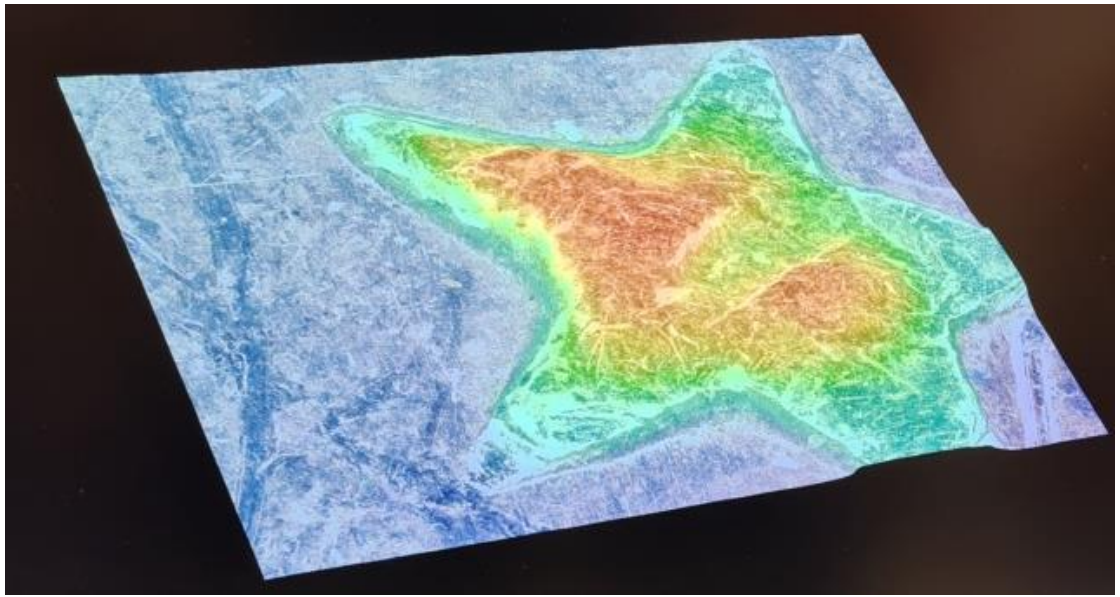


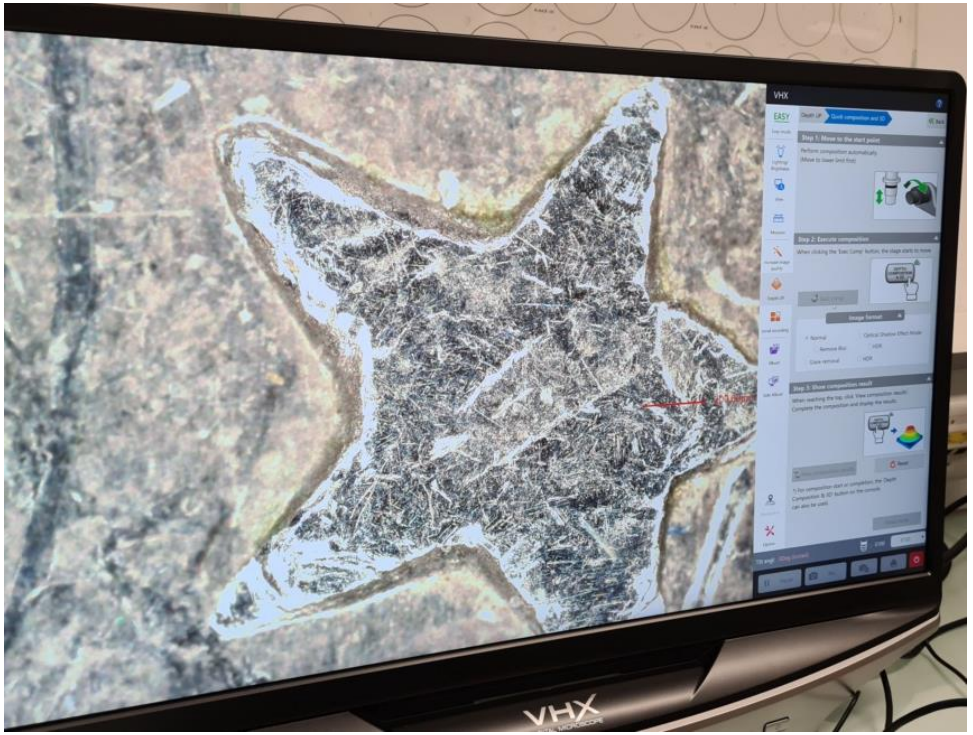


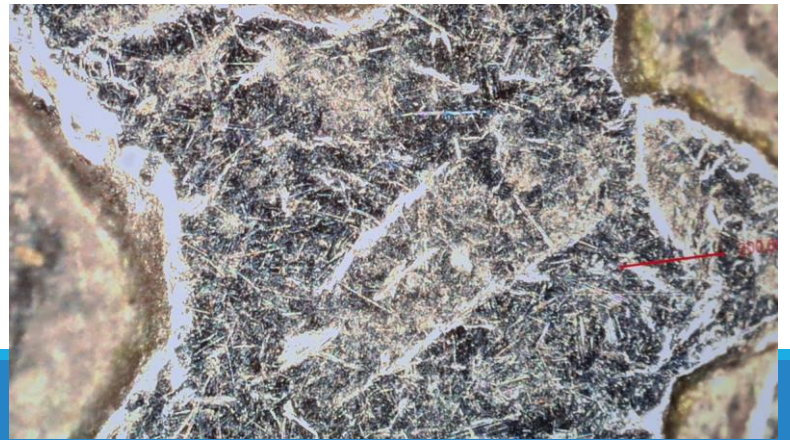
What is this? A city at night?



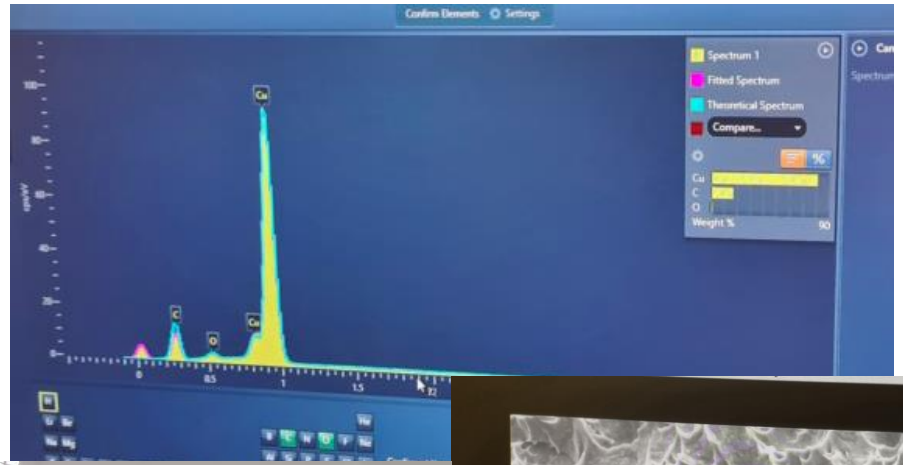
Bonus:
a star on 1 franc coin

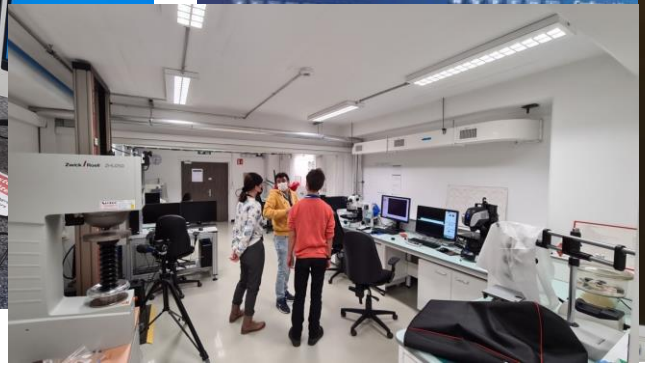


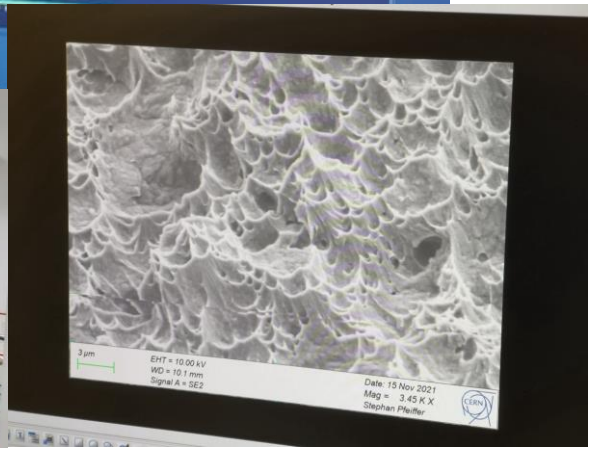




Scanning the material using an electron microscope and determining the chemical components (Cu, C, O)







Thank you for
your attention!