



# Romanian HSSIP 2021

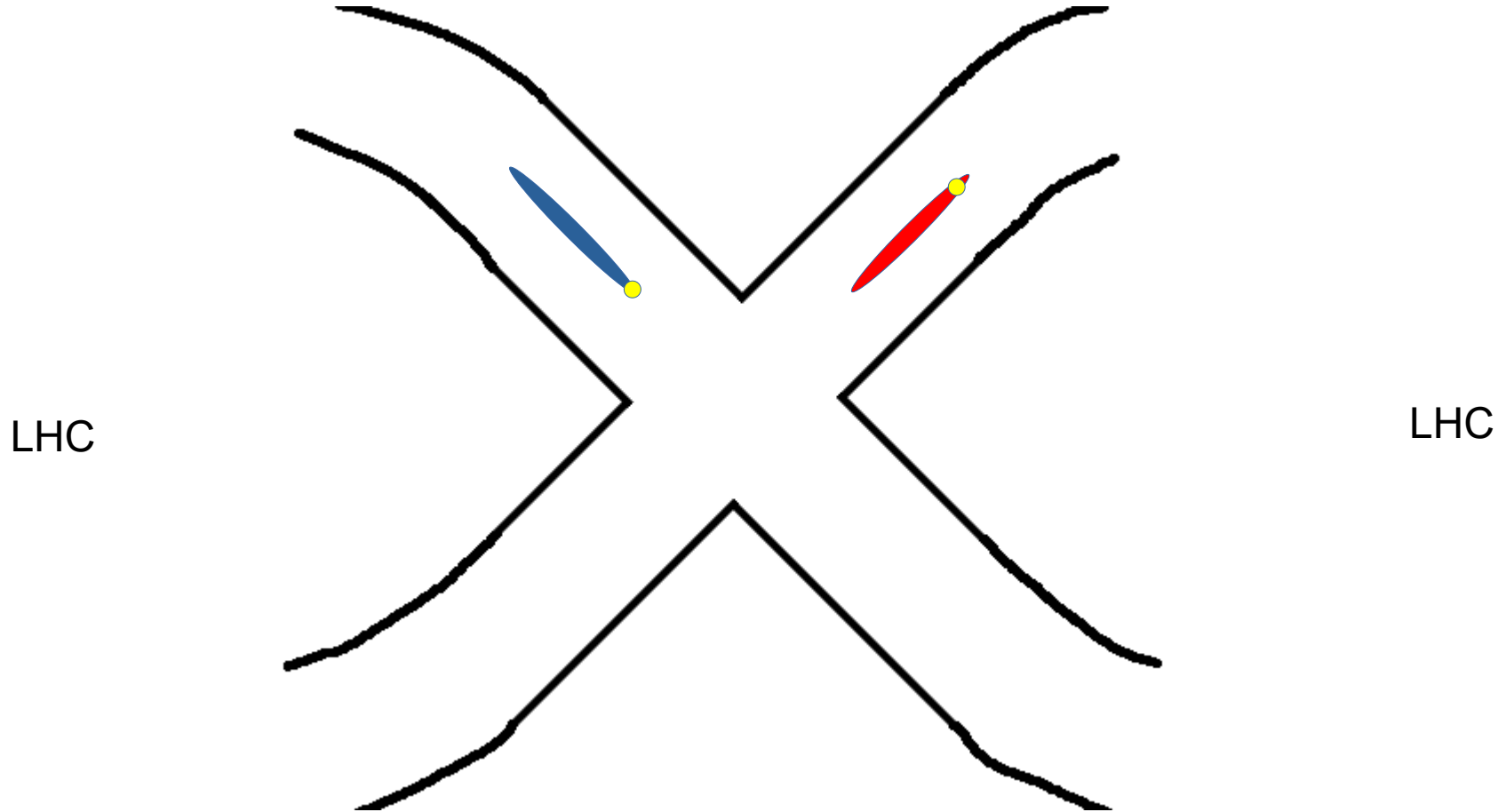
## Project 9: Life cycle of a component of an accelerator (crab cavities)

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ANDA-ALEXANDRA DRAGOMIR; CODRIN BERINDE  
SUPERVISORS: IULIANA TABIAN, OFELIA CAPATINA

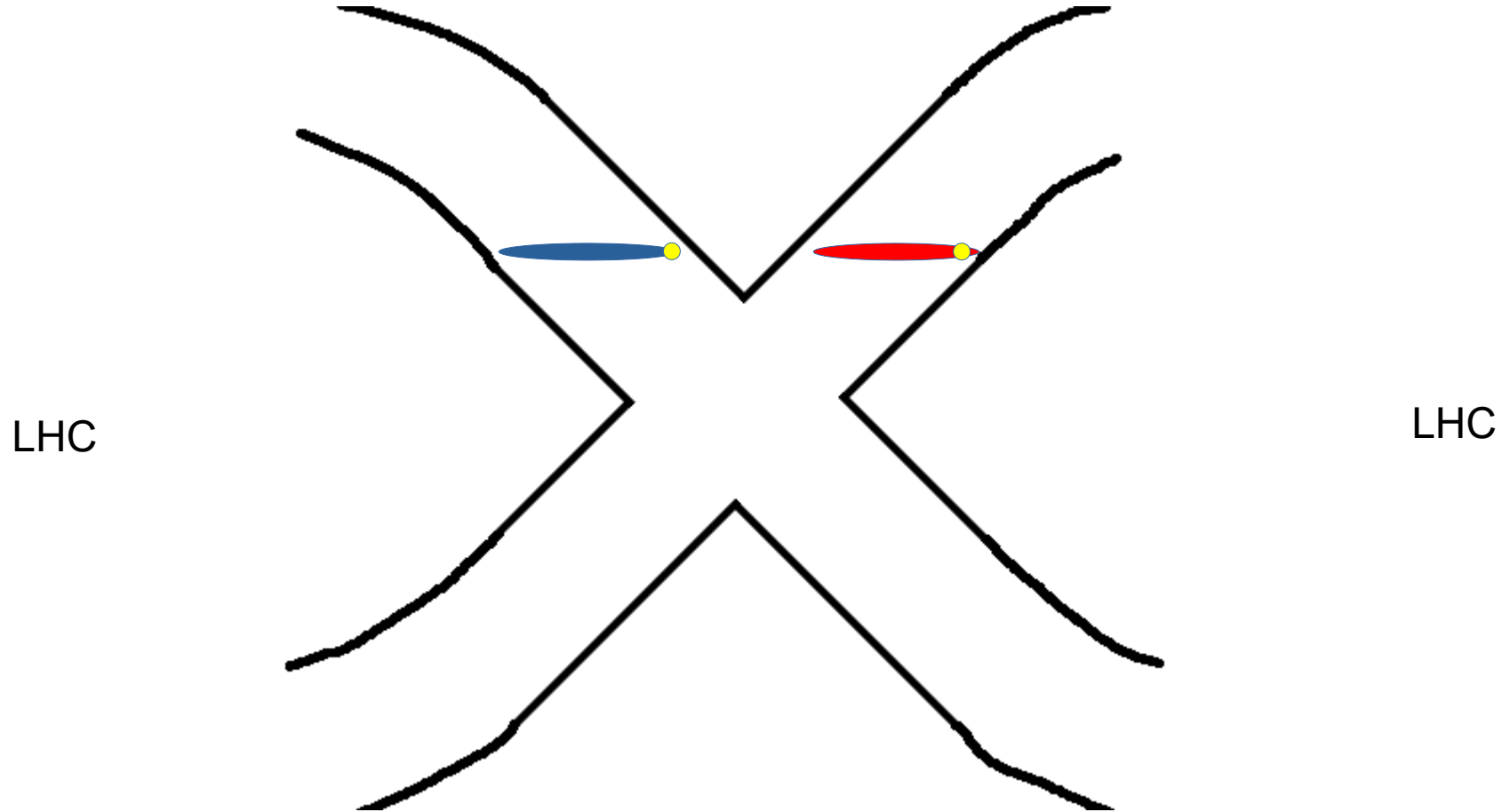
THANKS TO: FEDERICO CARRA, SIMON BARRIERE, ROMAIN NINET, ROMAIN GERARD, OSCAR SACRISSTAN DE FRUTOS, MICHAEL GUINCHARD, IGNACIO AVILES SANTILLANA, ADRIA GALLIFA TERRICABRAS, TEDDY CAPELLI, LUCIE BAUDIN, JORGE GUARDIA VALENZUELA, NIKOLINA VEJNOVIC, MARCO MASCI, LIVIA CARMEN COMAN, KEZIBAN KANDEMIR, VALENTINA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

# Collision at present

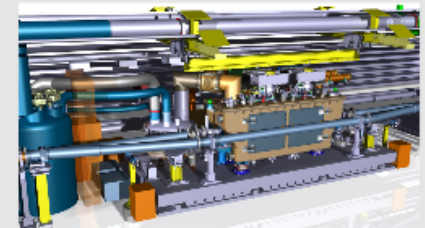
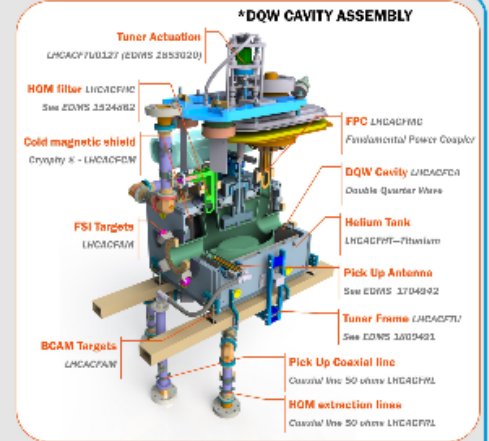
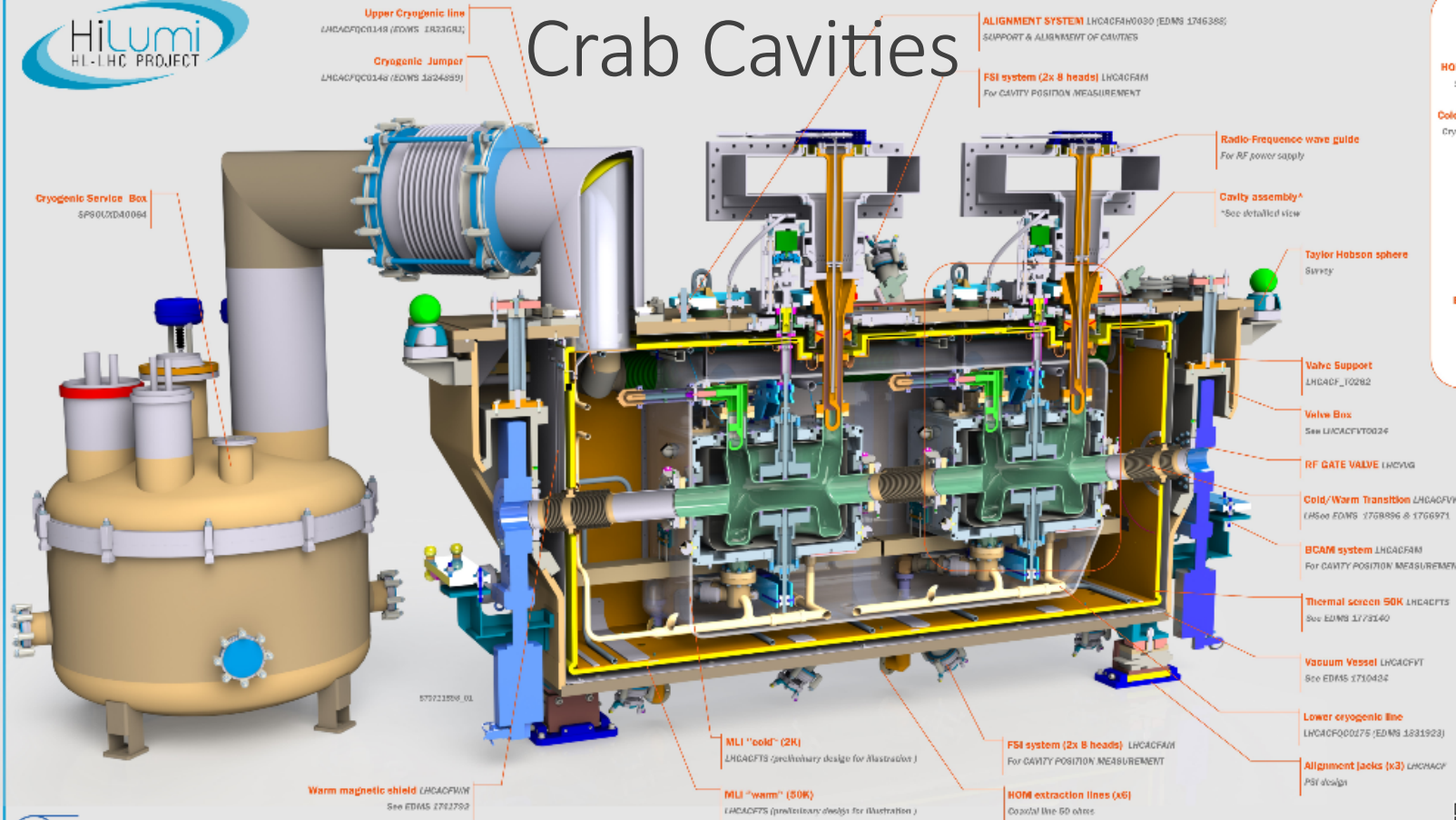




# With Crab Cavities



# Crab Cavities

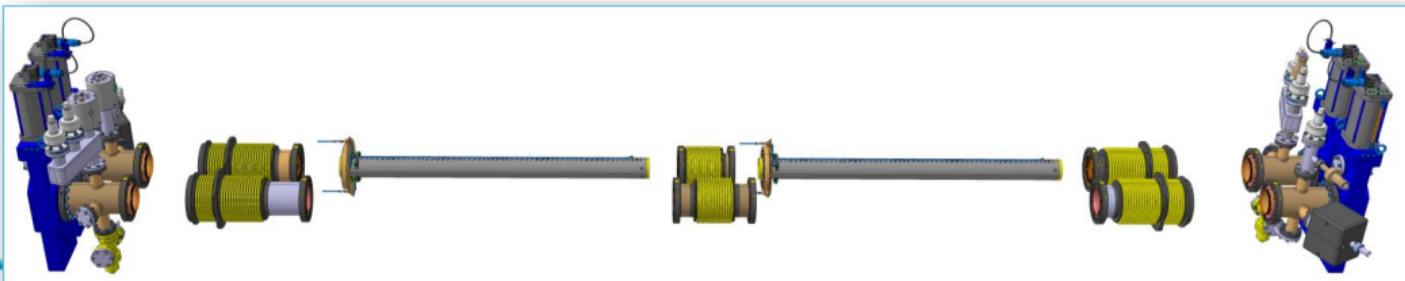
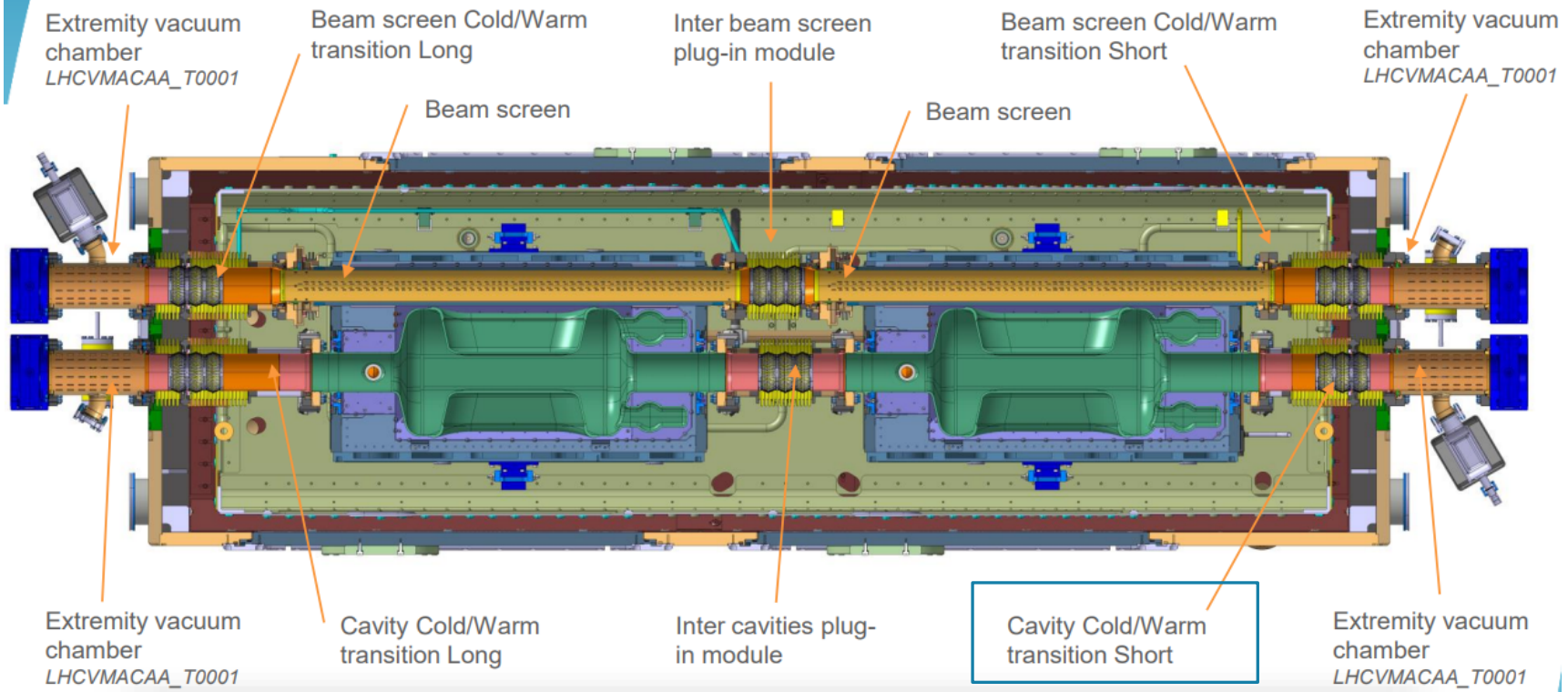


Information about DQW cryomodule

- Overall dimensions (L/l/h): 2800/950/1900mm
- Mass : ~3800kg (Without service box)
- Cavity : 2x DQW
- HOM filters : 6 pcs (3 per cavity)
- Pick Up Antenna : 2 pcs (1 per cavity)
- Tuner : 2 unit (1 per cavity)
- RF Gate valves : 2 pcs
- FSI Heads : 16 ports (8 per cavity)
- BCAM : 2 lines / 4 position fingers per cavity

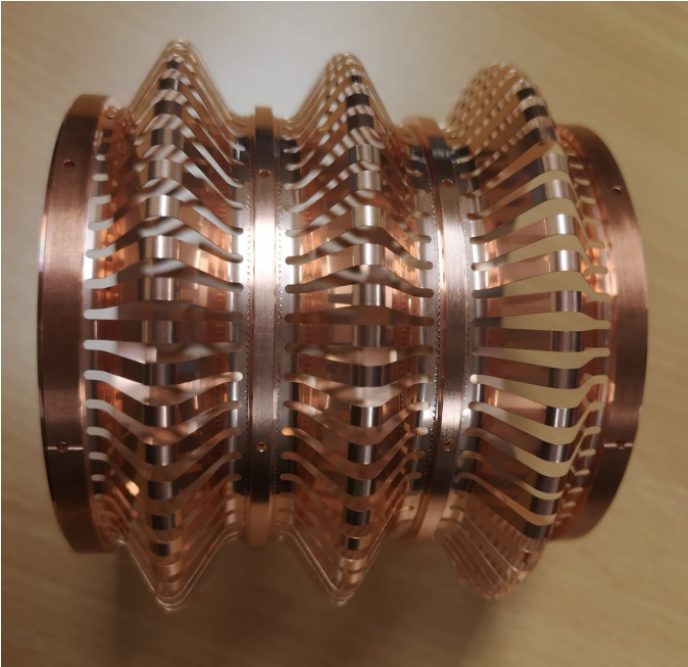
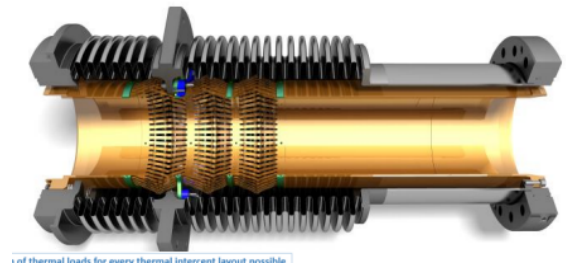


EDMS n° 1729225  
22-03-2027

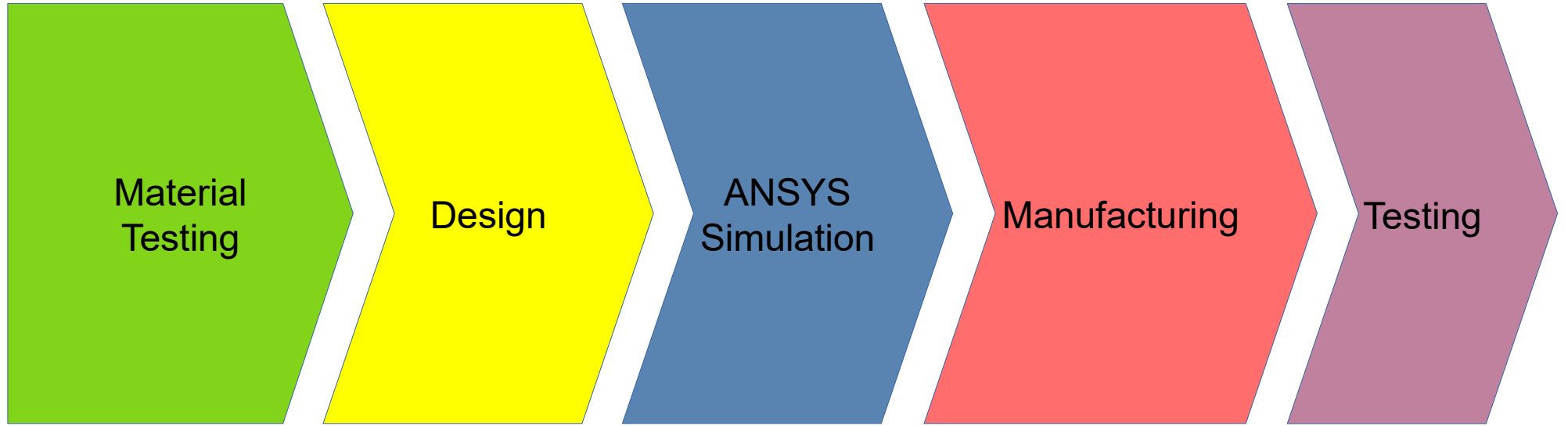


# The RF fingers

- 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



Material  
Testing

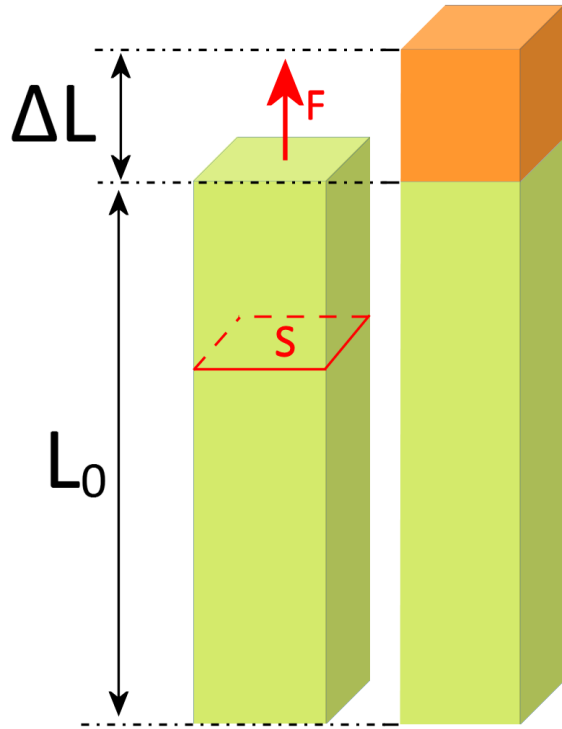
Design

ANSYS  
Simulation

Manufacturing

Testing

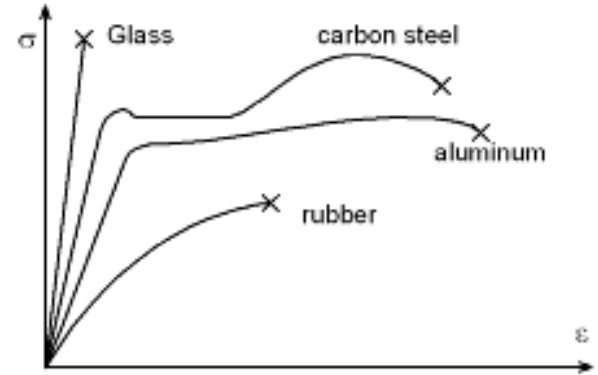
# Mechanical properties of a material



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

Hooke's Law:

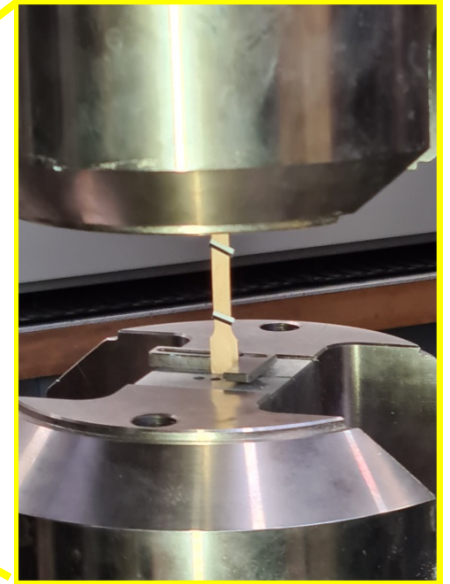
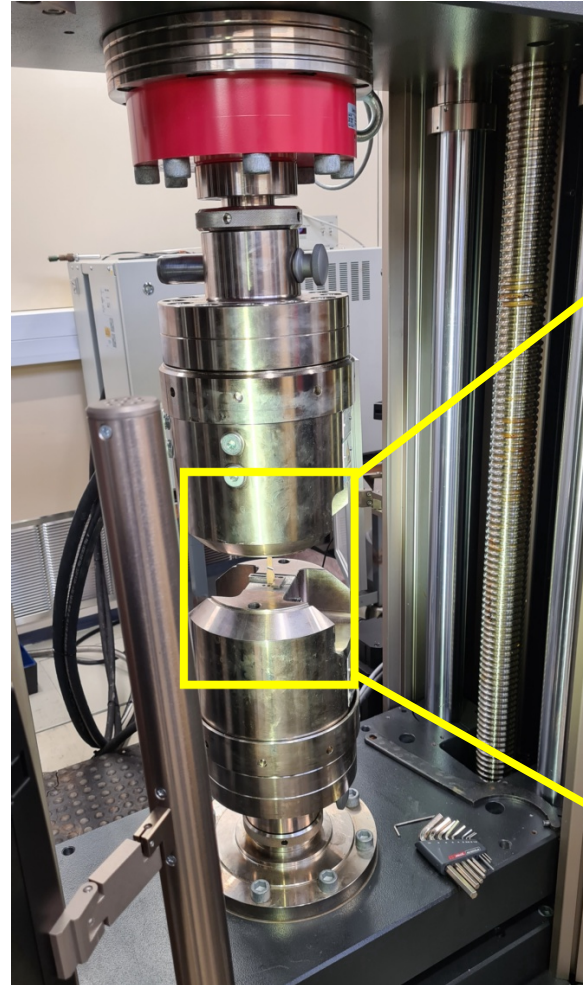
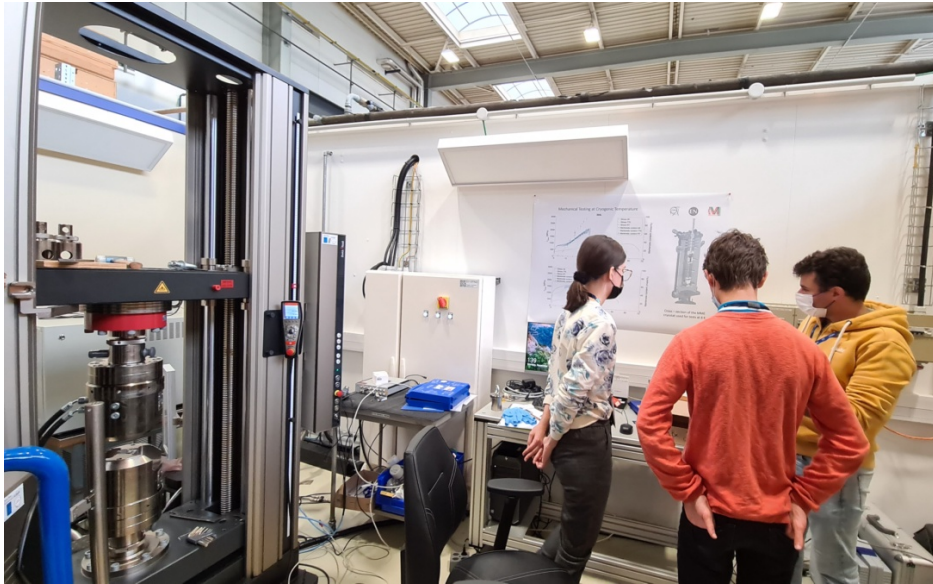
$$\sigma = E\varepsilon$$





# 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.

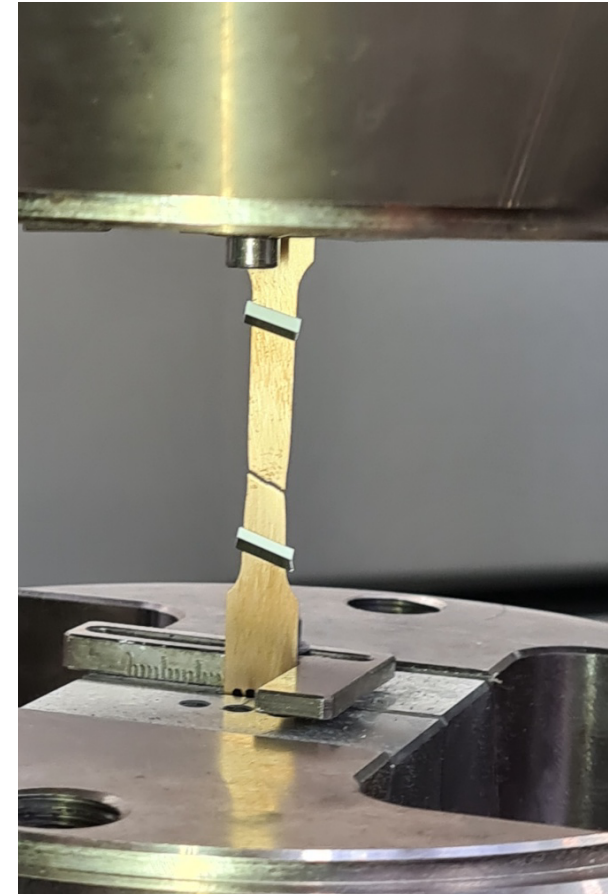


Tensile test

## Observing the behaviour of the component



## After the tensile test





# Results: stress-strain curve

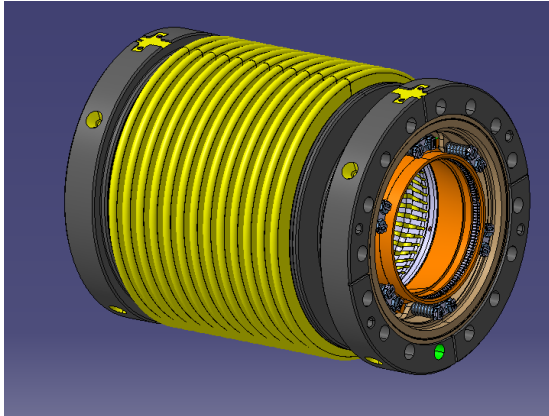
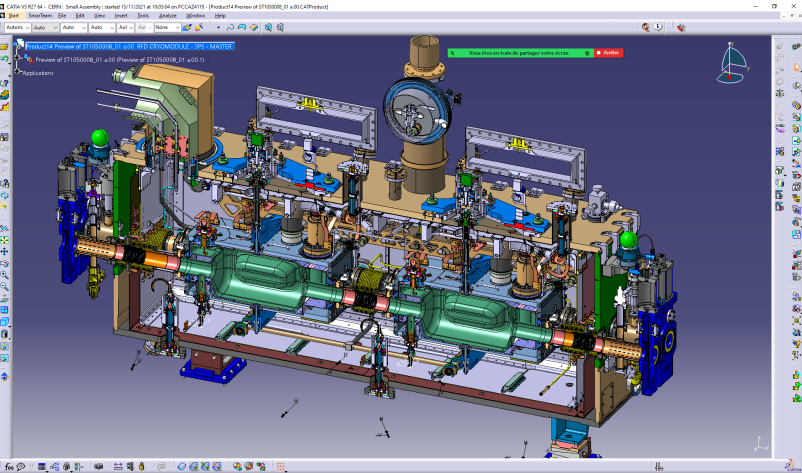
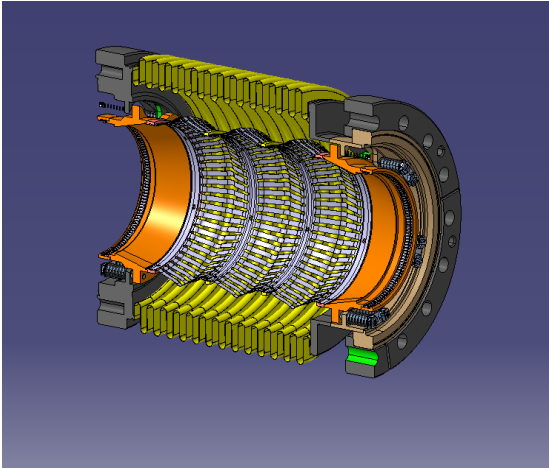
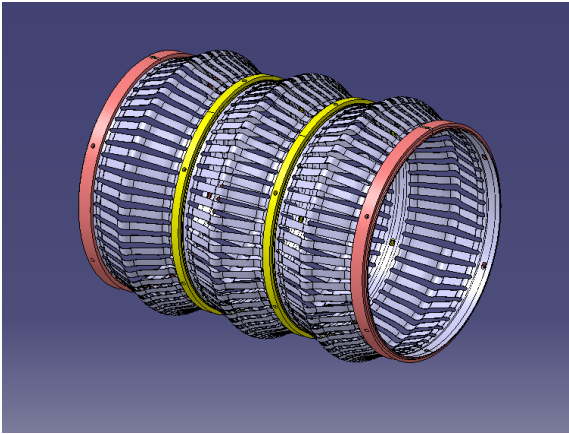
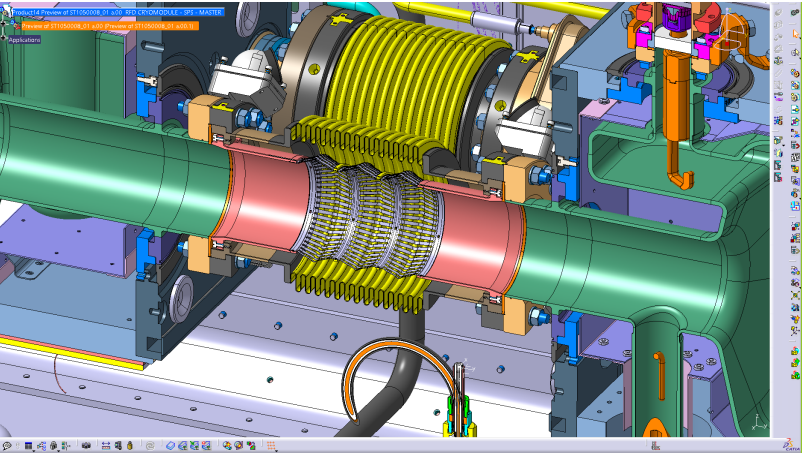


The initial slope is Young's modulus of elasticity (E)

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

Technical drawings illustrating the assembly procedure for crab cavities. The drawings include:

- A-A 1:1:** A detailed cross-sectional view of the crab cavity assembly, showing the internal structure and components.
- B-B 1:1:** A detailed cross-sectional view of a component, likely a support structure, showing its internal features.
- C-C 1:1:** A detailed cross-sectional view of another component, showing its internal features.
- D-D 1:1:** A detailed cross-sectional view of a component, showing its internal features.
- Exploded View:** A detailed view showing the assembly of the crab cavity components, including the support structures and the cavity itself.
- Assembly Diagrams:** Several diagrams showing the assembly of the crab cavity components, including the support structures and the cavity itself.
- Material List Table:** A table listing the materials used in the assembly, including their grades and quantities.

Technical drawing of an Aluminium flange. The drawing includes:

- Top View:** A detailed view of the flange showing its dimensions and features.
- Side View:** A detailed view of the flange showing its thickness and internal features.
- Section A-A 1:1:** A detailed cross-sectional view of the flange, showing its internal structure and features.
- Section D-D 1:1:** A detailed cross-sectional view of the flange, showing its internal structure and features.
- Material List Table:** A table listing the materials used in the flange, including their grades and quantities.

Aluminium flange

## RF fingers

Technical drawing of RF fingers. The drawing includes:

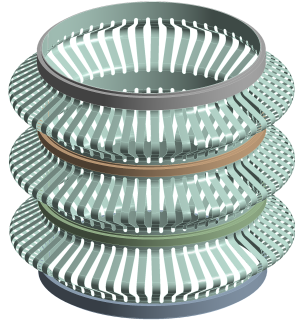
- Top View:** A detailed view of the RF fingers showing their circular shape and internal structure.
- Section A-A 2:1:** A detailed cross-sectional view of the RF fingers, showing their internal structure and features.
- Section B 4:1:** A detailed cross-sectional view of the RF fingers, showing their internal structure and features.
- Alignment View:** A detailed view showing the alignment of the RF fingers, highlighting the engraved marks.
- Material List Table:** A table listing the materials used in the RF fingers, including their grades and quantities.

ALIGNMENT VIEW OF ENGRAVED MARKS

BILL OF MATERIALS		REV. NO.	
ITEM NO.	DESCRIPTION	QUANTITY	REVISION
01	RF Fingers and Ring	1	01
02	RF Fingers and Ring	1	01
03	RF Fingers and Ring	1	01
04	RF Fingers and Ring	1	01
05	RF Fingers and Ring	1	01
06	RF Fingers and Ring	1	01
07	RF Fingers and Ring	1	01
08	RF Fingers and Ring	1	01
09	RF Fingers and Ring	1	01
10	RF Fingers and Ring	1	01
11	RF Fingers and Ring	1	01
12	RF Fingers and Ring	1	01
13	RF Fingers and Ring	1	01
14	RF Fingers and Ring	1	01
15	RF Fingers and Ring	1	01
16	RF Fingers and Ring	1	01
17	RF Fingers and Ring	1	01
18	RF Fingers and Ring	1	01
19	RF Fingers and Ring	1	01
20	RF Fingers and Ring	1	01
21	RF Fingers and Ring	1	01
22	RF Fingers and Ring	1	01
23	RF Fingers and Ring	1	01
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25	RF Fingers and Ring	1	01
26	RF Fingers and Ring	1	01
27	RF Fingers and Ring	1	01
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100	RF Fingers and Ring	1	01

# Simulations in ANSYS

18/11/2021 11:25



**D: WithoutFlanges**

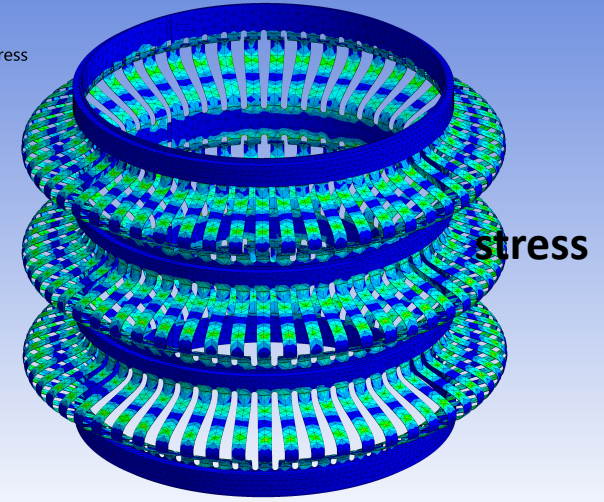
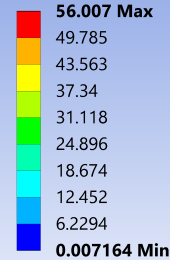
Equivalent Stress

Type: Equivalent (von-Mises) Stress

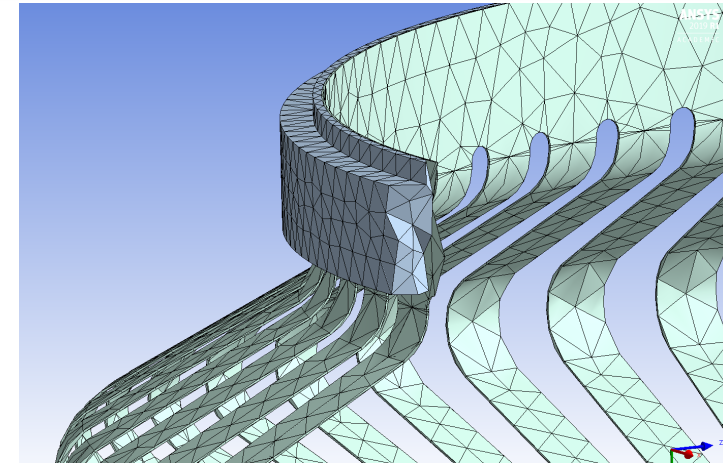
Unit: MPa

Time: 1

18/11/2021 17:17



- 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





C:\Without flanges - Mechanical [ANSYS Academic Research Mechanical and CFD]

File Edit View Units Tools Help

Solve New Analysis ?/ Show Errors

Show Vertices Close Vertices 1.7e-004 (Auto Scale) Wireframe Show Mesh Random Preferences

Result 11 (Auto Scale) Edge Coloring

Outline

Filter: Name

Project\*

- Model (C4)
  - Geometry
  - Materials
  - Coordinate Systems
  - Connections
  - Mesh
  - Stable Structural (C5)
    - Analysis Settings
    - Force
    - Fixed Support
  - Solution (C6)
    - Solution Information
    - Total Deformation

C: Without flanges  
Total Deformation  
Type: Total Deformation  
Unit: m  
Time: 1  
15/11/2021 17:55

0.00079695 Max  
0.0007094  
0.00061985  
0.0005313  
0.00044275  
0.0003542  
0.00026565  
0.0001771  
8.855e-5  
0 Min

ANSYS 2019 R1 ACADEMIC

Details of "Total Deformation"

Scope

Scoping Method: Geometry Selection  
Geometry: All Bodies

Definition

Type: Total Deformation  
By: Time  
Display Time: Last  
Calculate Time History: Yes  
Identifier:  
Suppressed: No

Results

Minimum: 0. m  
Maximum: 7.9695e-004 m  
Average: 3.9994e-004 m  
Minimum Occurs On: ST1335899\_03:PartBody  
Maximum Occurs On: ST1335899\_03:PartBody

Information

Geometry | Print Preview | Report Preview

Graph

Animation 20 Frames 2 Sec (Auto) 3 Cycle

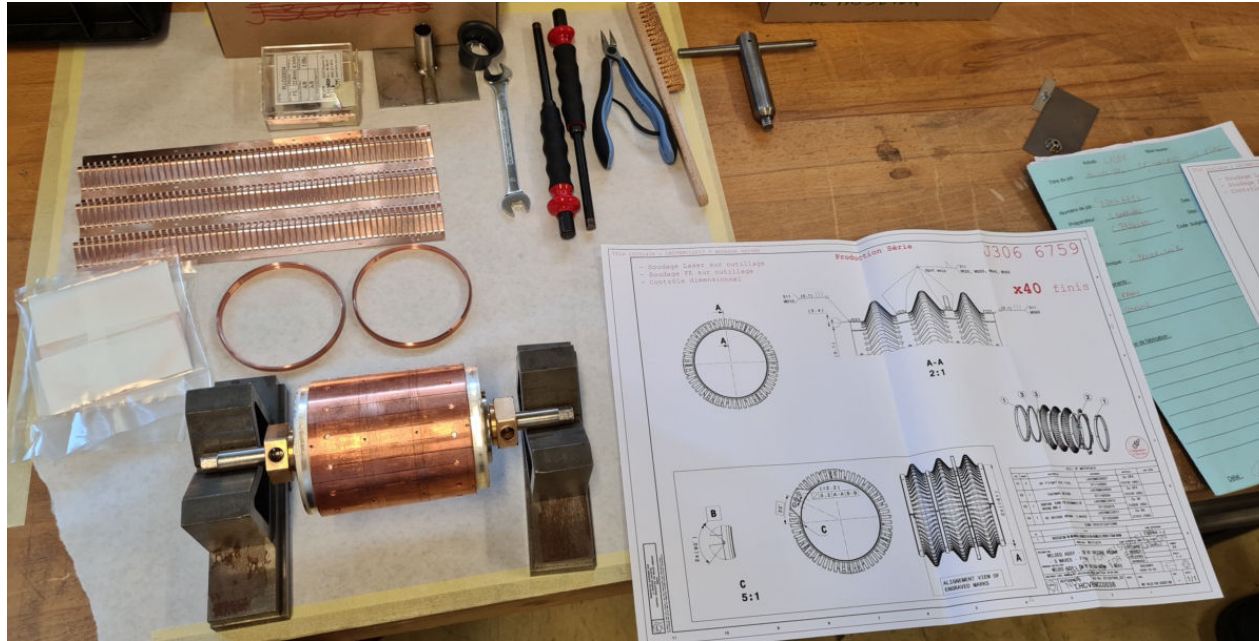
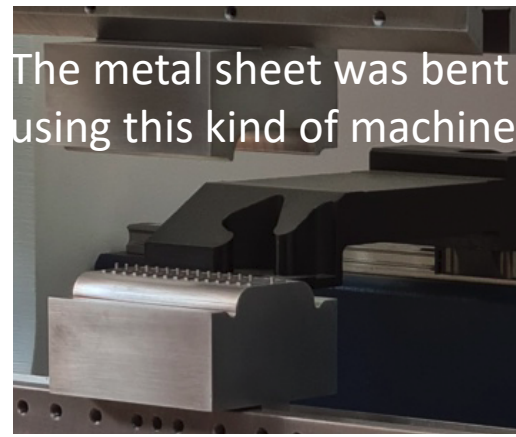
Tabular Data

Time [s]	Minimum [m]	Maximum [m]	Average [m]
1   1.	0.	7.9695e-004	3.9994e-004

Metric (m, kg, N, s, V, A) Degrees rad/s Celsius  
7°C Stark bewölkt ENG 17:55  
US 15/11/2021

# Manufacturing

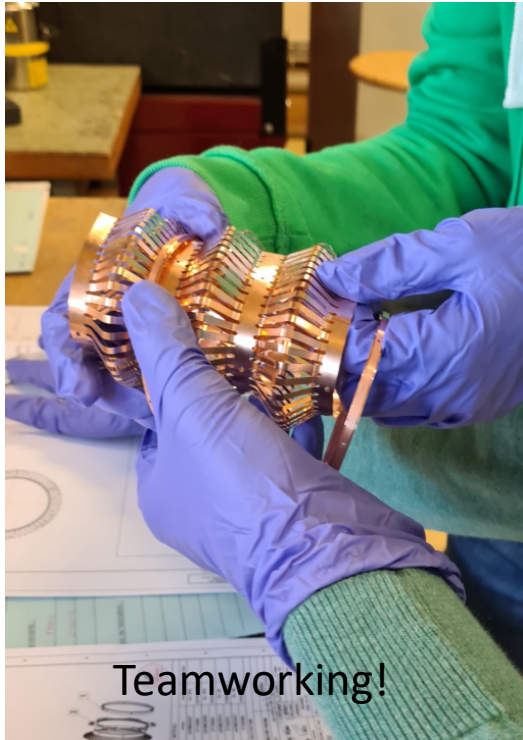
All the necessary parts & tools:



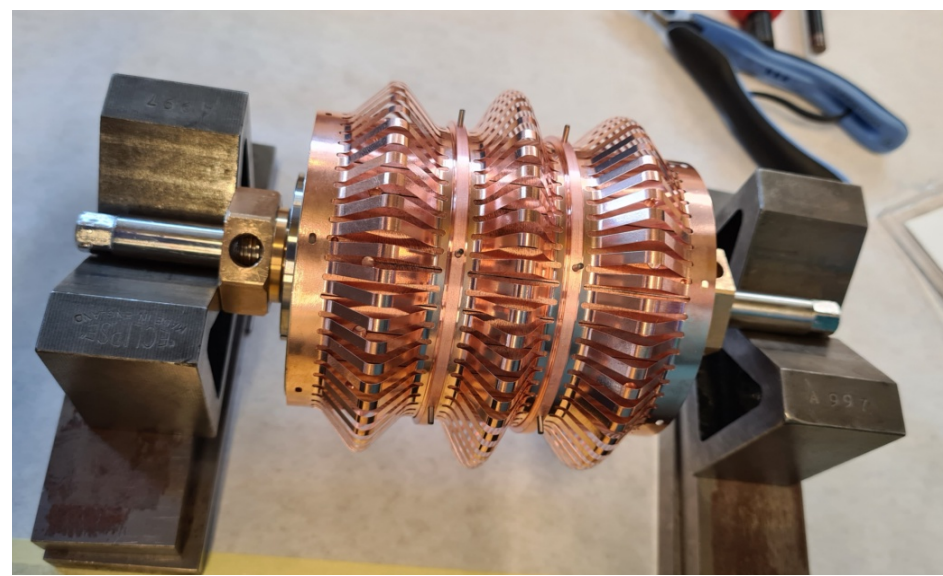


# Assembly

Putting the parts together



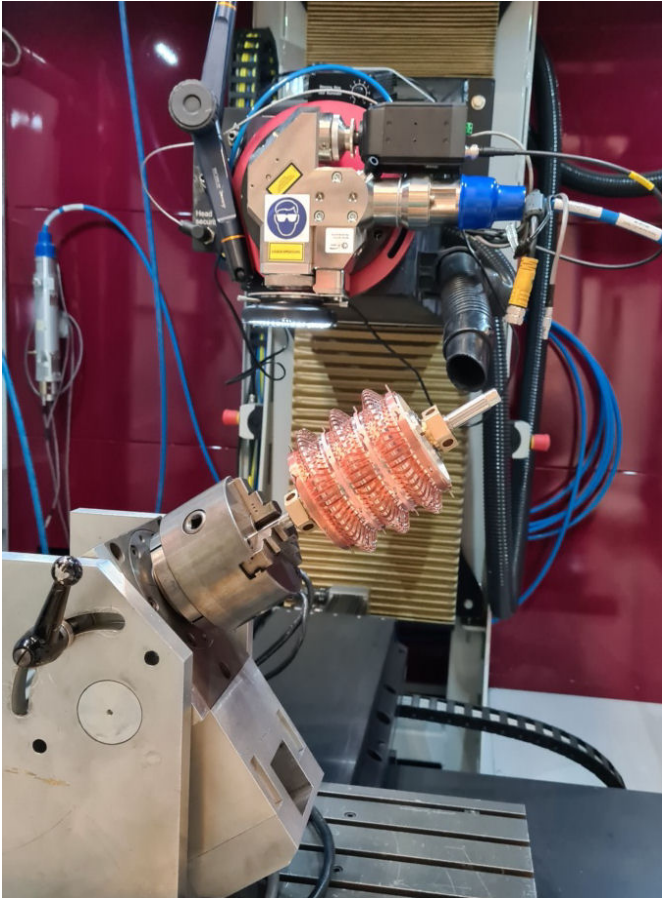
Teamworking!



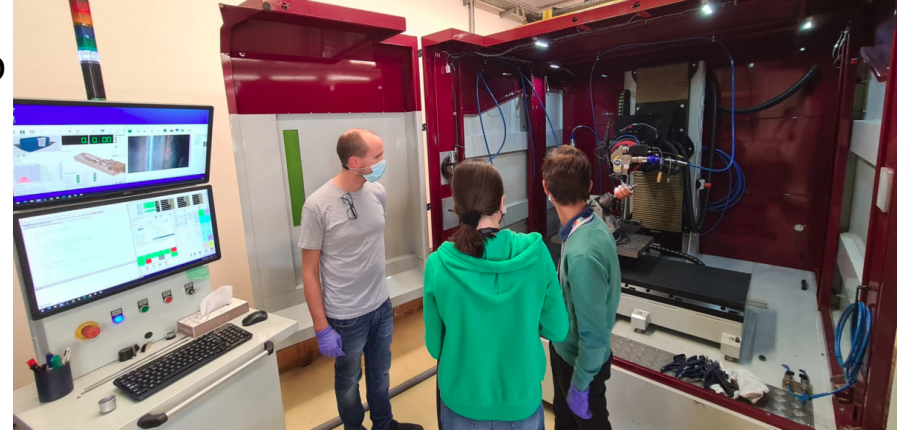
After bending, the rings must be welded onto the sheet.  
For the welding process, the component was put on a support.



# Machining technique: Laser Welding

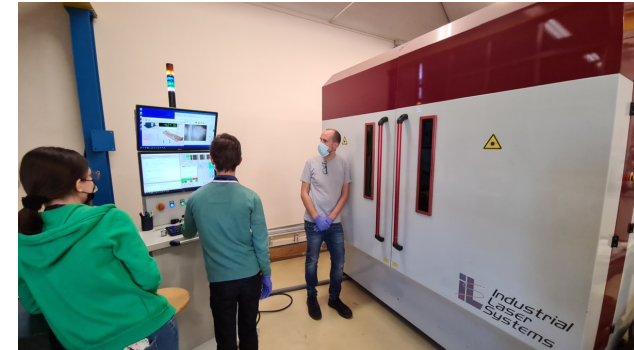


Fixing the component into the welding machine



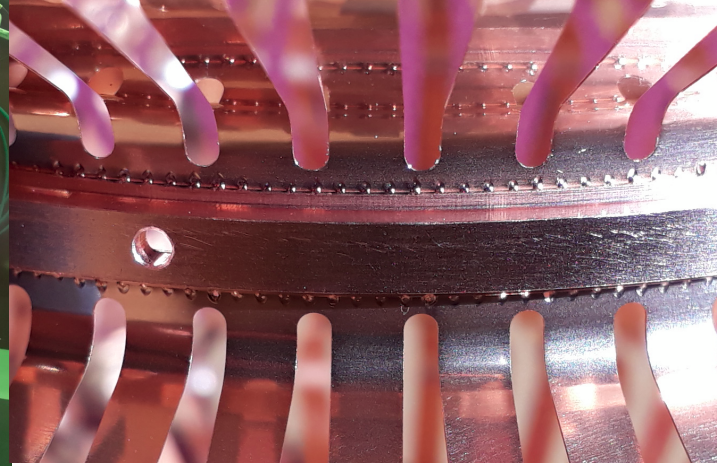
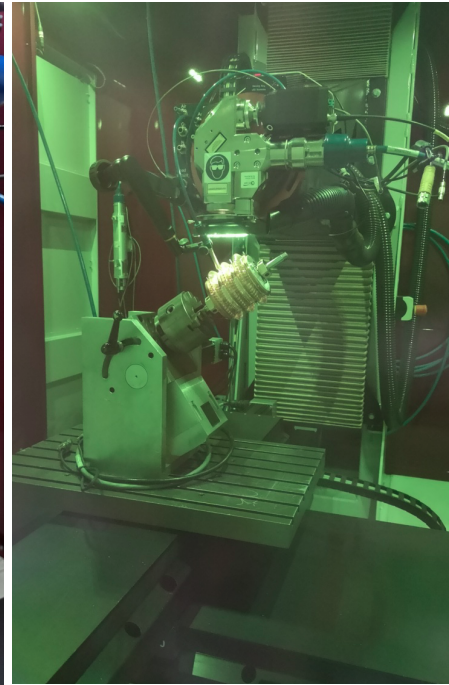
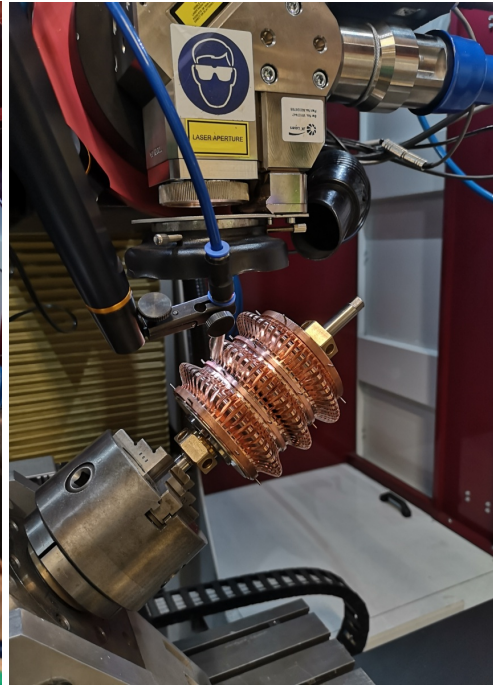
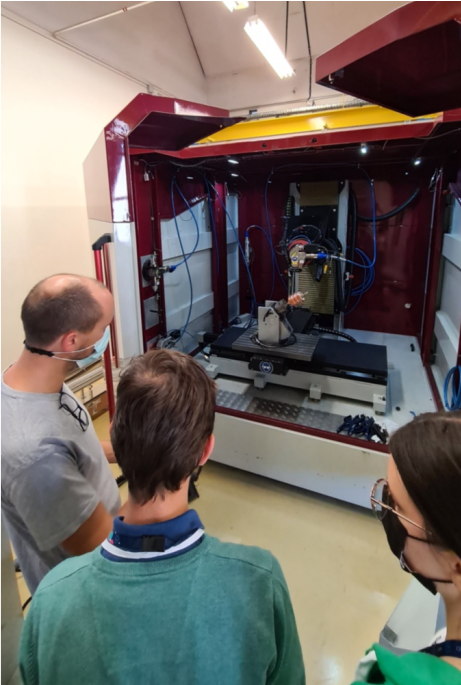
A quick check before pressing the big green button

... 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.

Measuring the block  
of material

Calibrating the piece



The milling machine

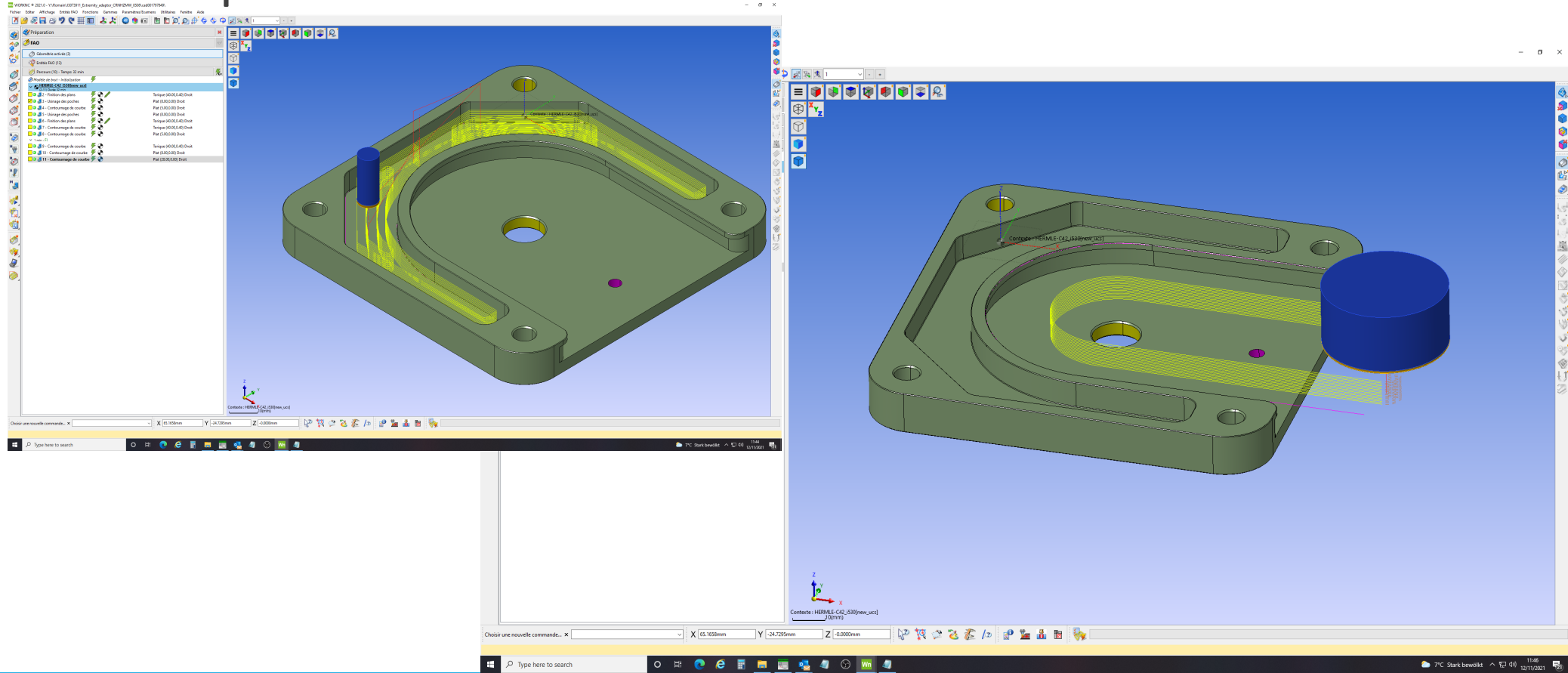


The initial piece of Aluminium

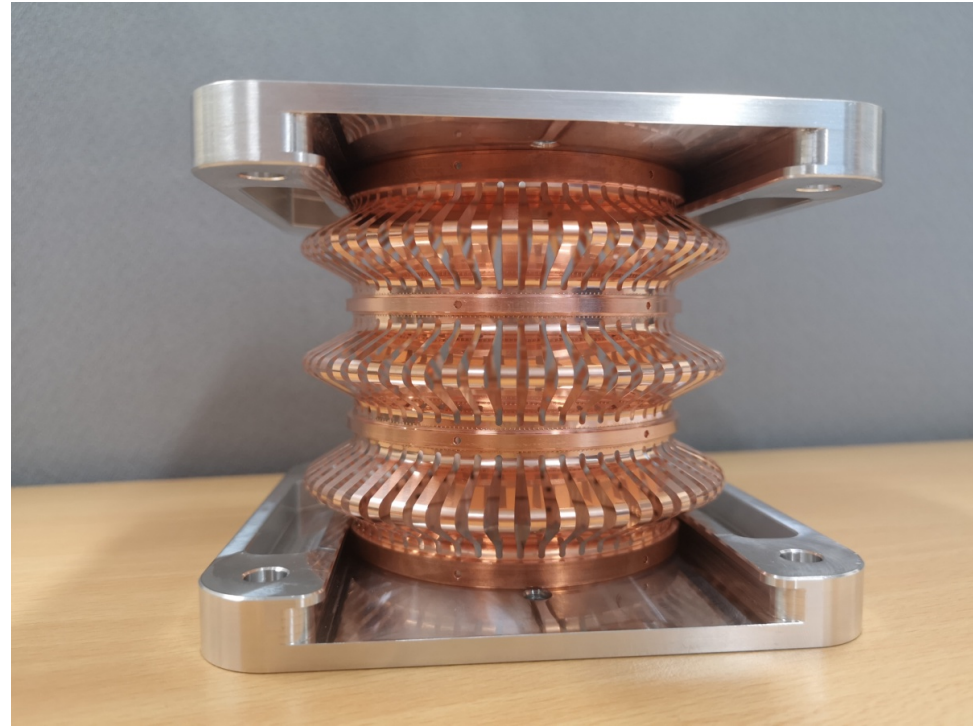




# Programming the milling pattern on the computer



# After milling



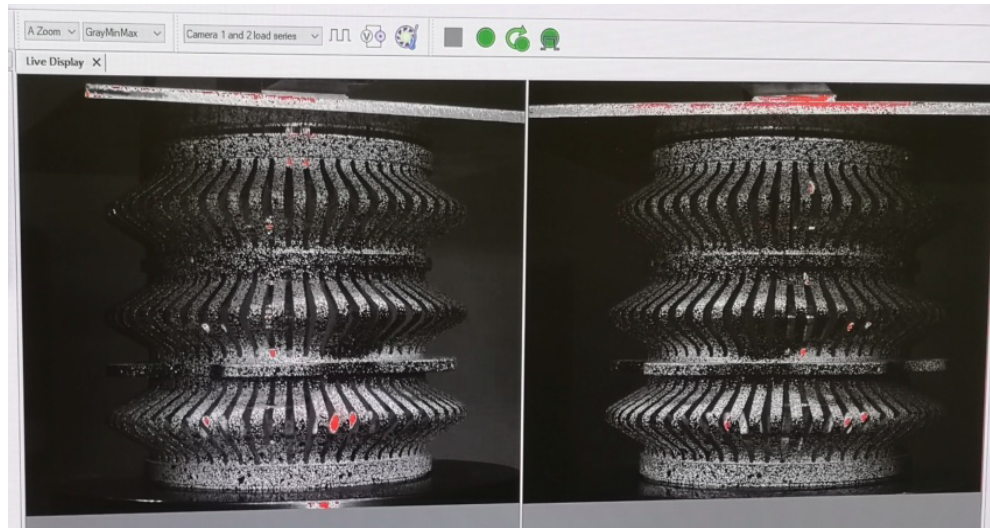
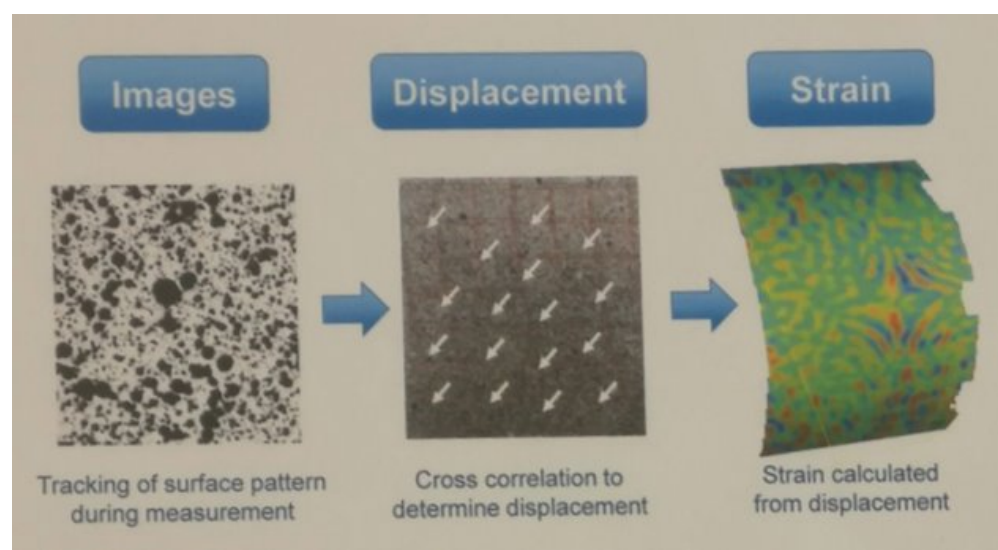
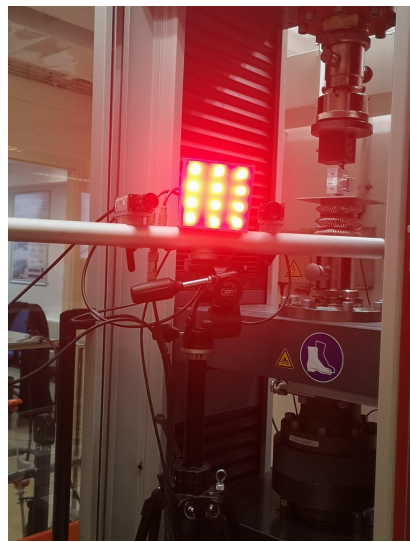
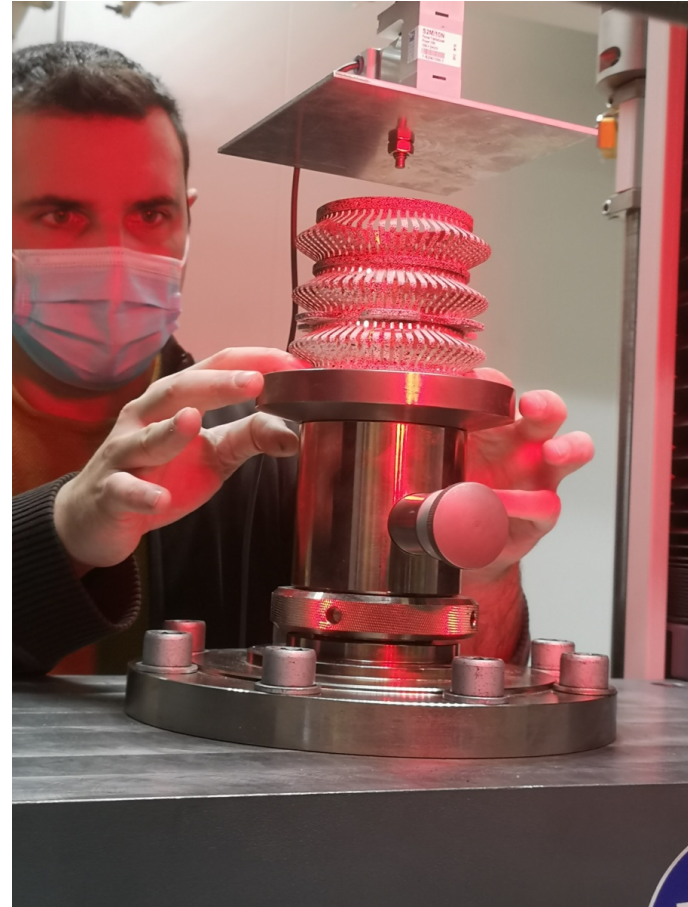
# Testing the component

- 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.



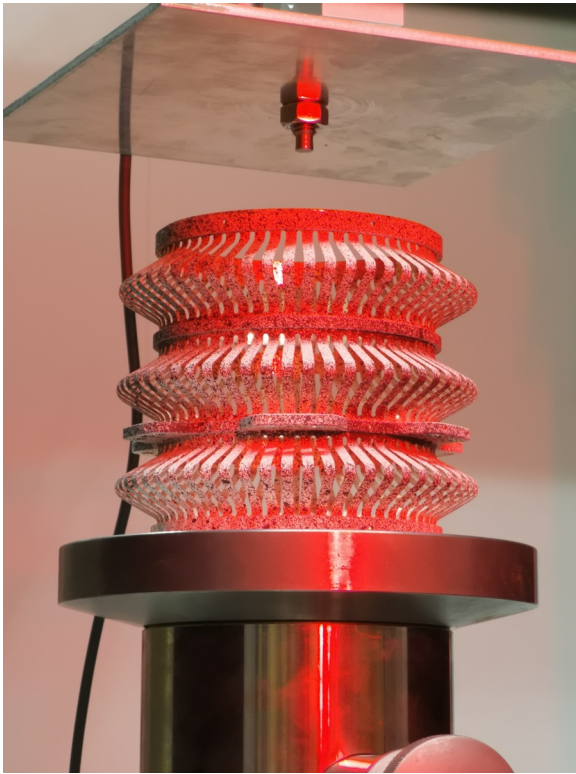


Fixing the component into the machine

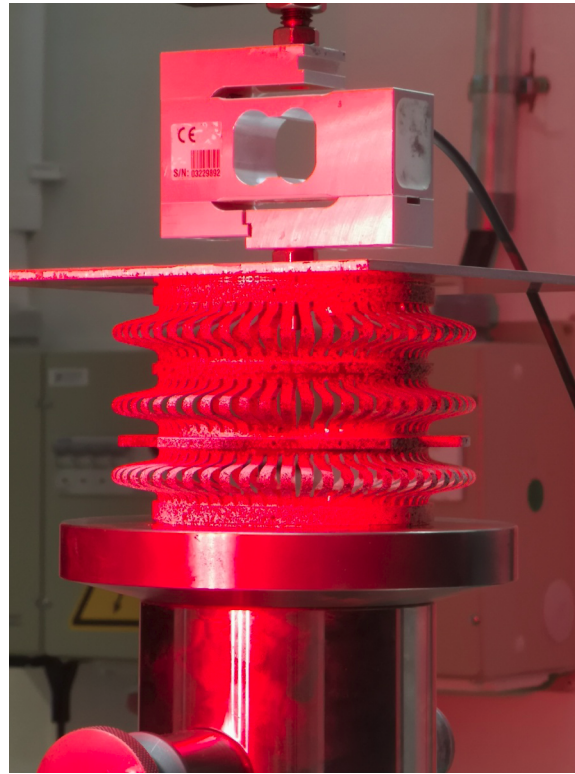


Digital Image Correlation (DIC)

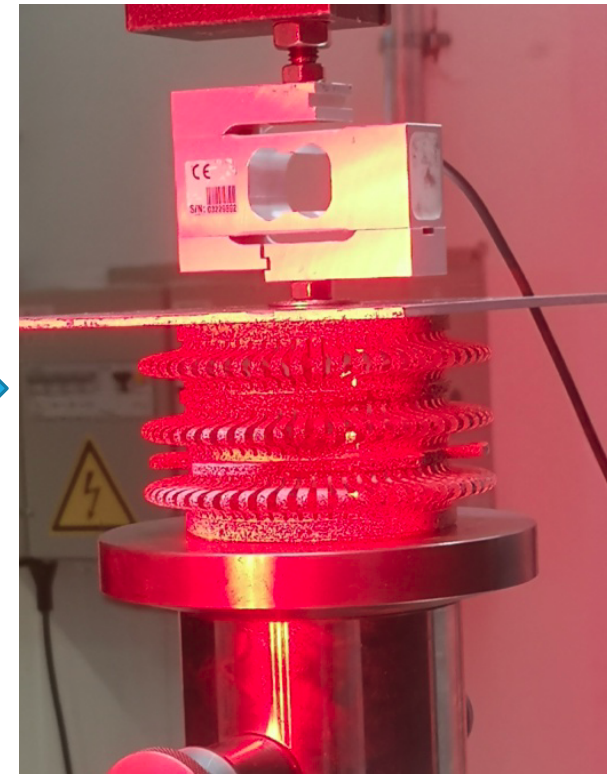
# Testing the component through compression



0 N



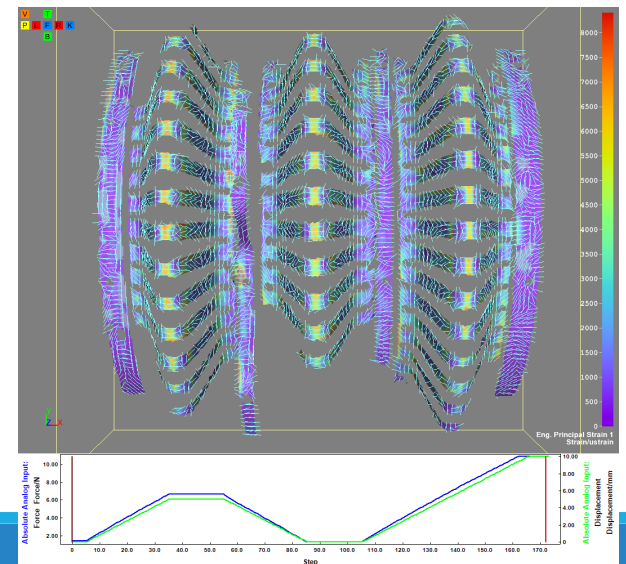
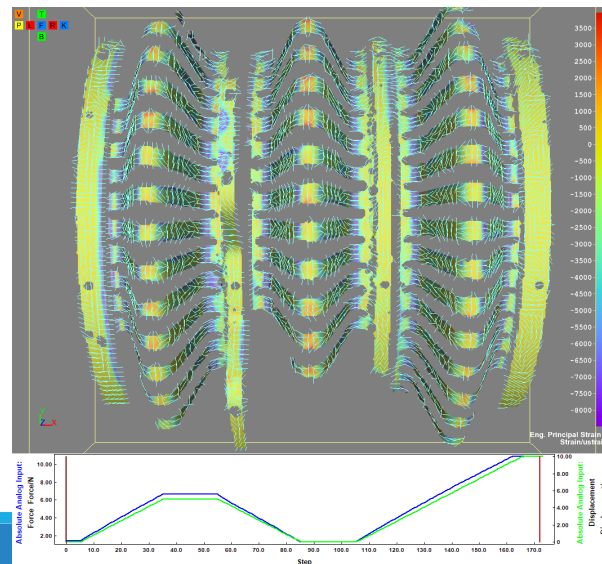
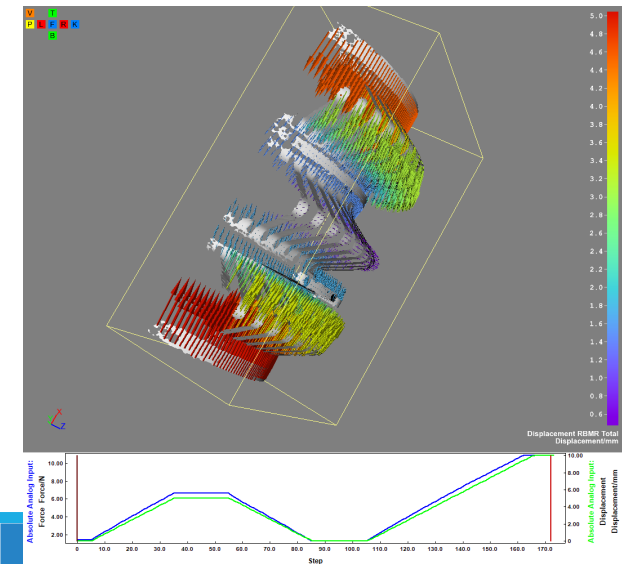
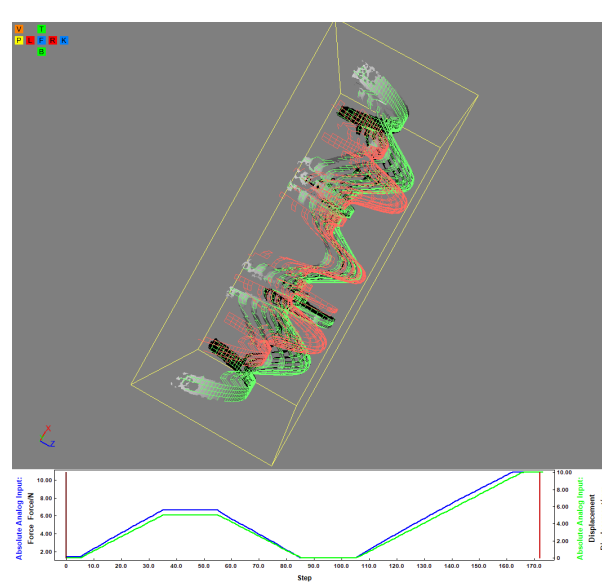
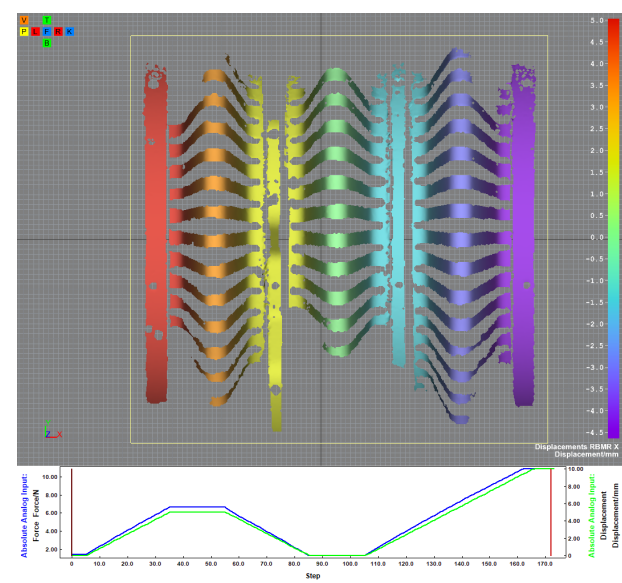
10 N



20 N



# Displacement obtained from DIC



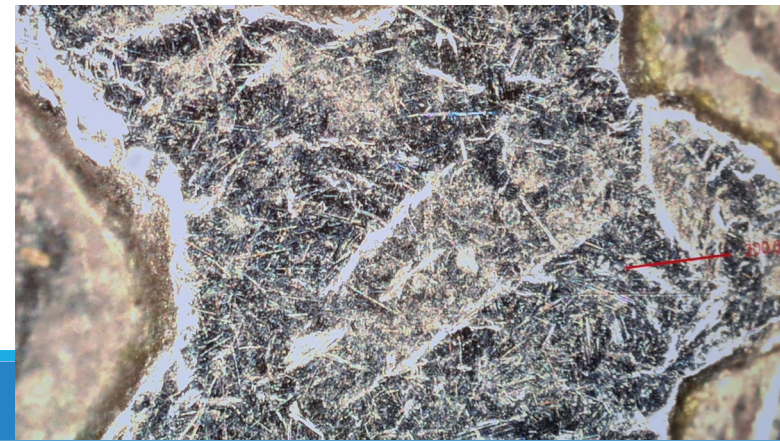
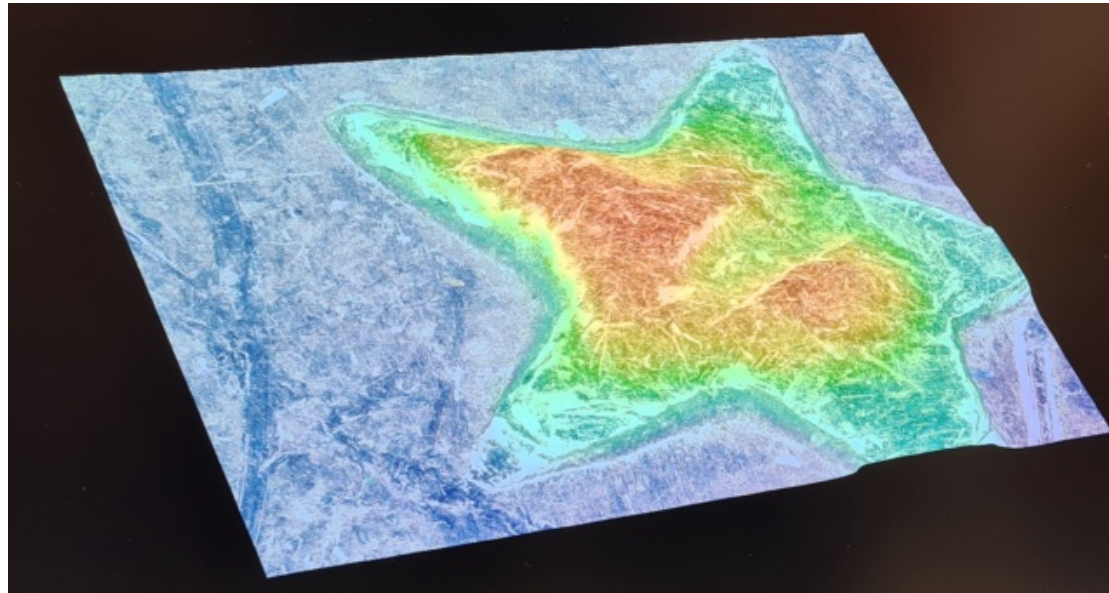


What is this? A city at night?



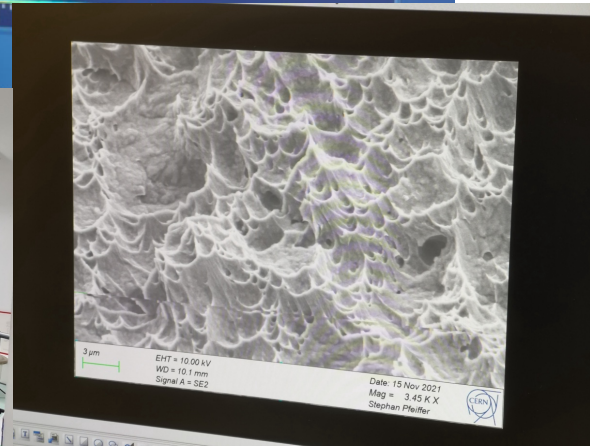
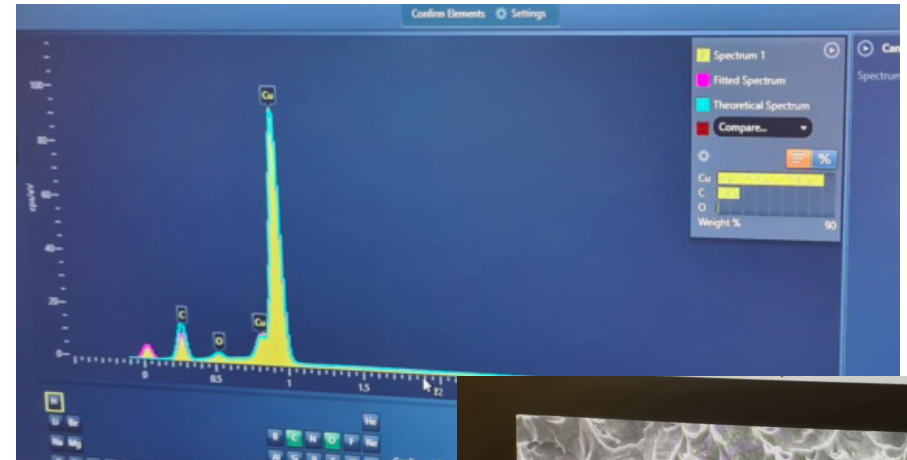
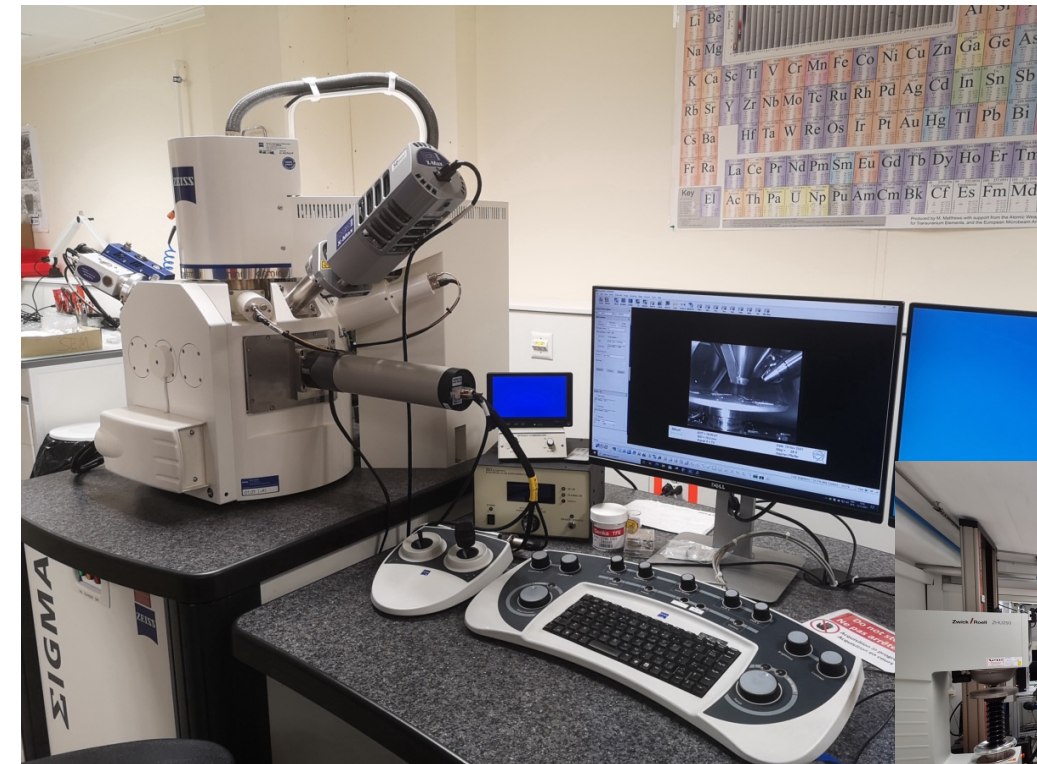


# Bonus: a star on 1 franc coin





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



Thank you for  
your attention!

