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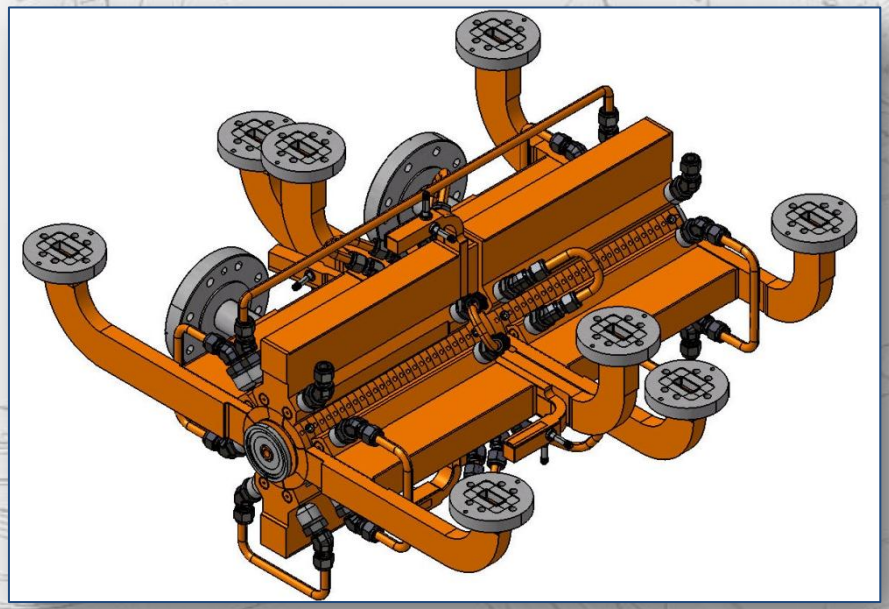
Assembly procedure of TD26_CC_SiC

F. Rossi



06-September-2011

INTRODUCTION

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ACCELERATING STRUCTURE

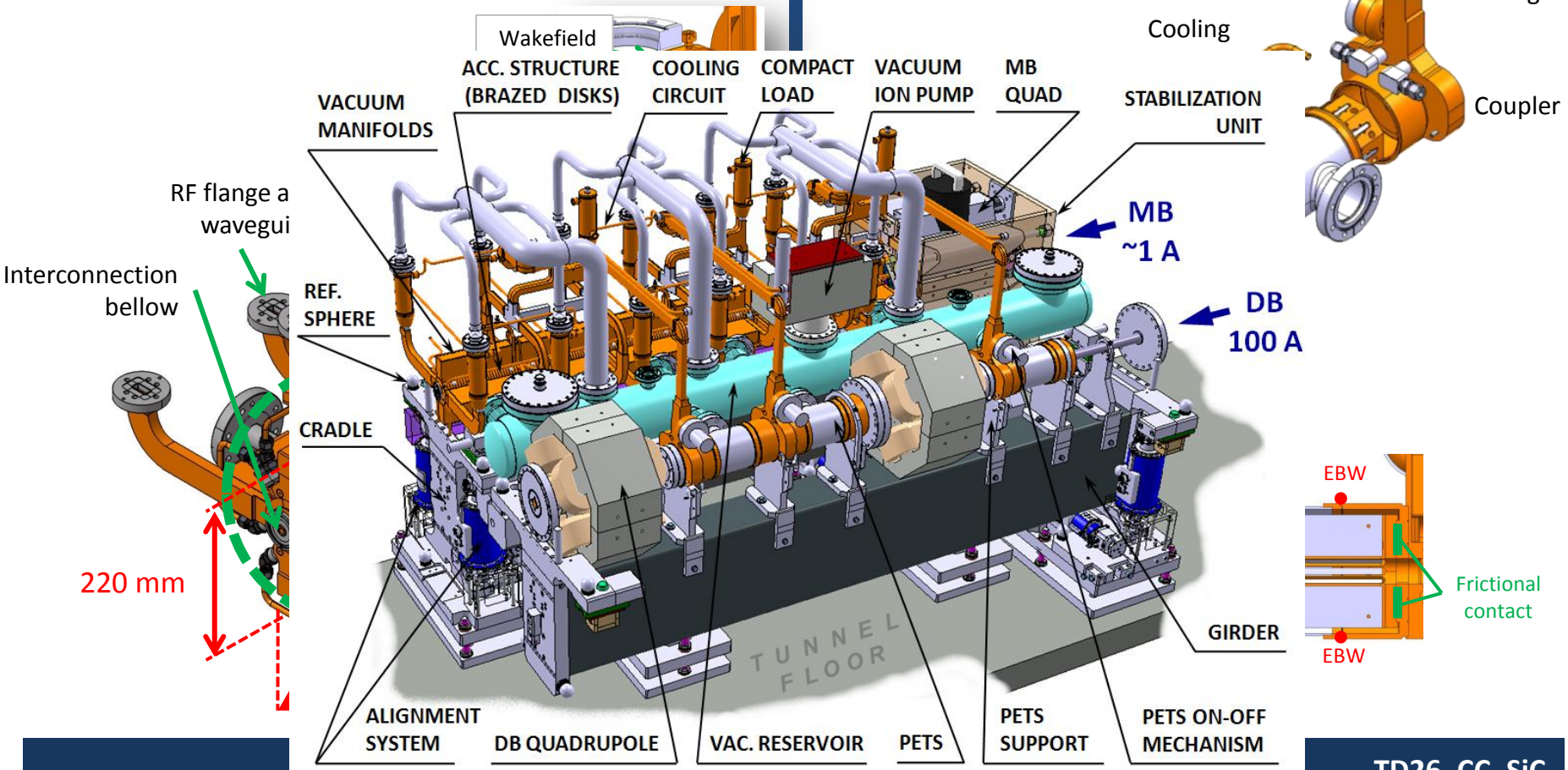
REQUIREMENTS

- COAXILITY ERROR: < 10 µm
- ALIGNMENT ERROR BETWEEN MANIFOLDS AND DISKS STACK: ±10 µm

PETS

REQUIREMENTS

- COAXILITY ERROR: < 25 µm



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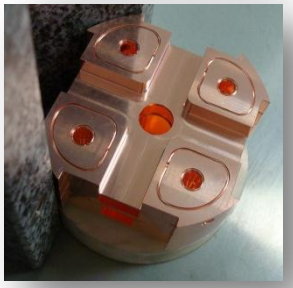
Main technologies involved in the assembly procedure:

- Bonding (atmosphere: H_2, temperature: ~1000 °C)

- Brazing (atmosphere: H_2 or vacuum, temperature: ~1000 °C, brazing alloy: AuCu or AgCu)



- EBW

- (Laser welding)

STEPS

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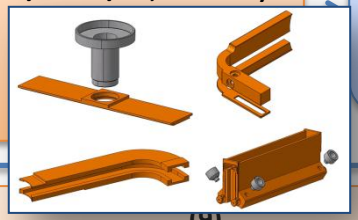
(1) MACHINING

(2) QUALITY CONTROL
1. Inlet inspection
2. Dimensional control
3. SEM
4. Preliminary RF tests

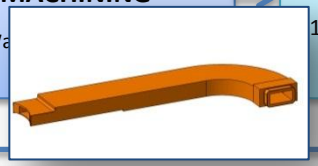
(3) CLEANING
1. Etching with SLAC solution
2. Degreasing + deoxidation + passivation

(4) H_2 DIFFUSION BONDING (1040 °C)
1. Disks stack (x2)

(5) H_2 BRAZING (Au/Cu 25/75, 1040 °C)
1.
2.
3.
4.

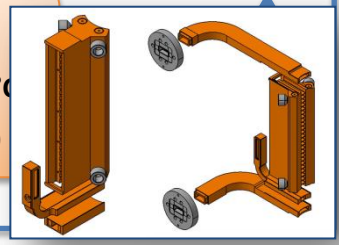


(6) MACHINING
1. Wa

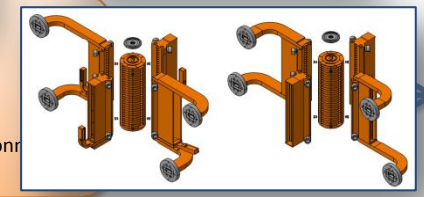


(7) CLEANING
1. Degreasing + deoxidation + passivation

(8) H_2 BRAZING (Au/Cu 25/75, 1040 °C
1. Vacuum manifolds (x6)

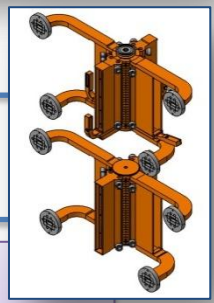


(9) H_2 BRAZING (Au/Cu 35/65, 1020 °C)
1. 4 vacuum manifolds + 1 disks stack + 1 interconn flange + 8 steel inserts + tuning studs (x2)

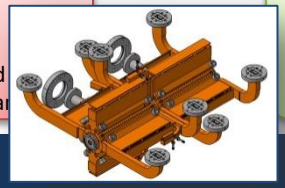


(10) QUALITY CONTROL
1. Vacuum test
2. Cooling circuit test

(11) H_2 BRAZING (Au/Cu 50/50, 980 °C)
1. 2 accelerating structures



(12) EBW
1. Covers and vacuum fla



(13) QUALITY CONTROL
1. Vacuum test

(14) RF CHECK AND TUNING

(15) VACUUM BAKING (650 °C, 10 days)

(16) CONDITIONING

WORKFLOW: AS 1

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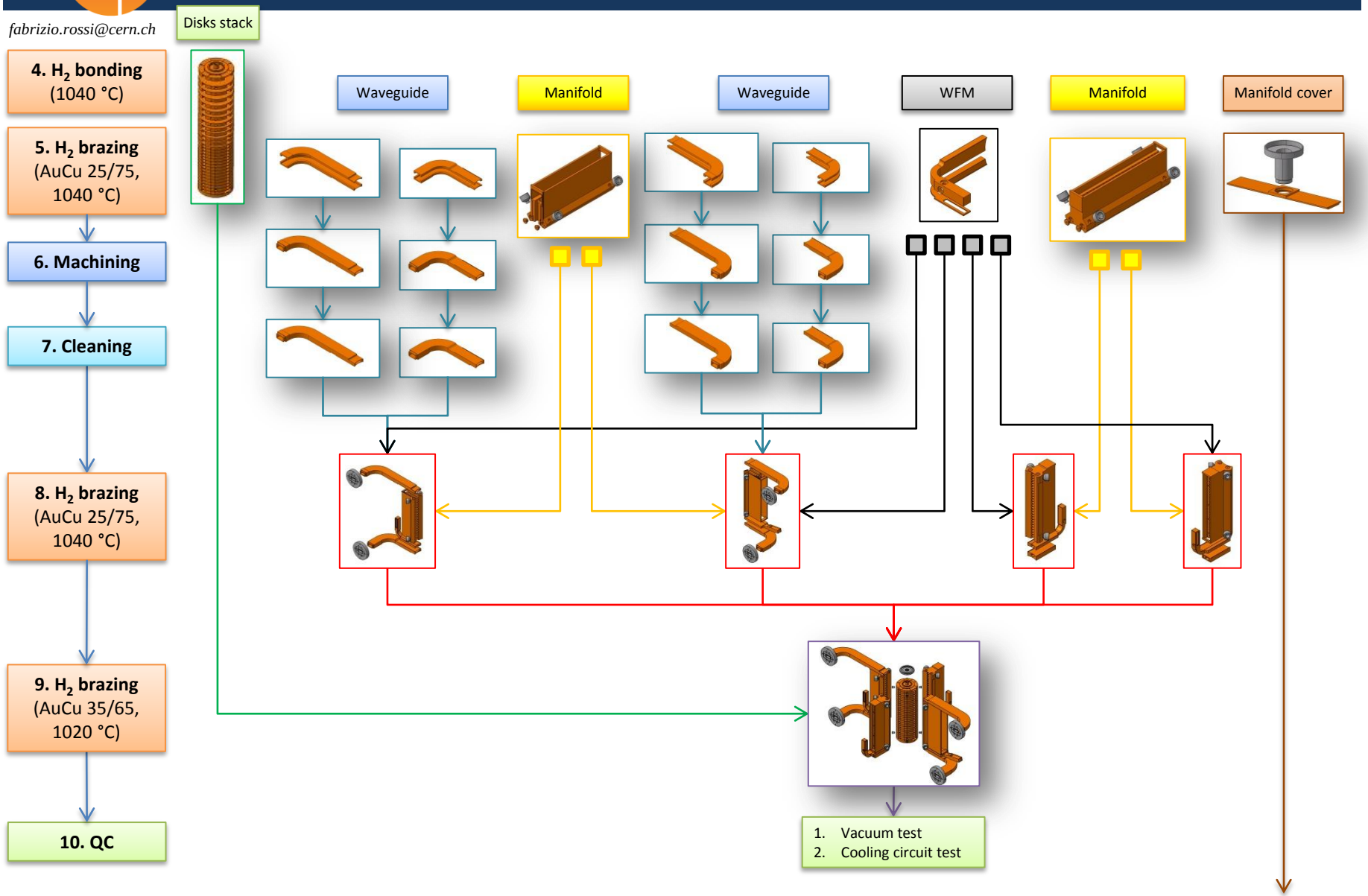

WORKFLOW: AS 2

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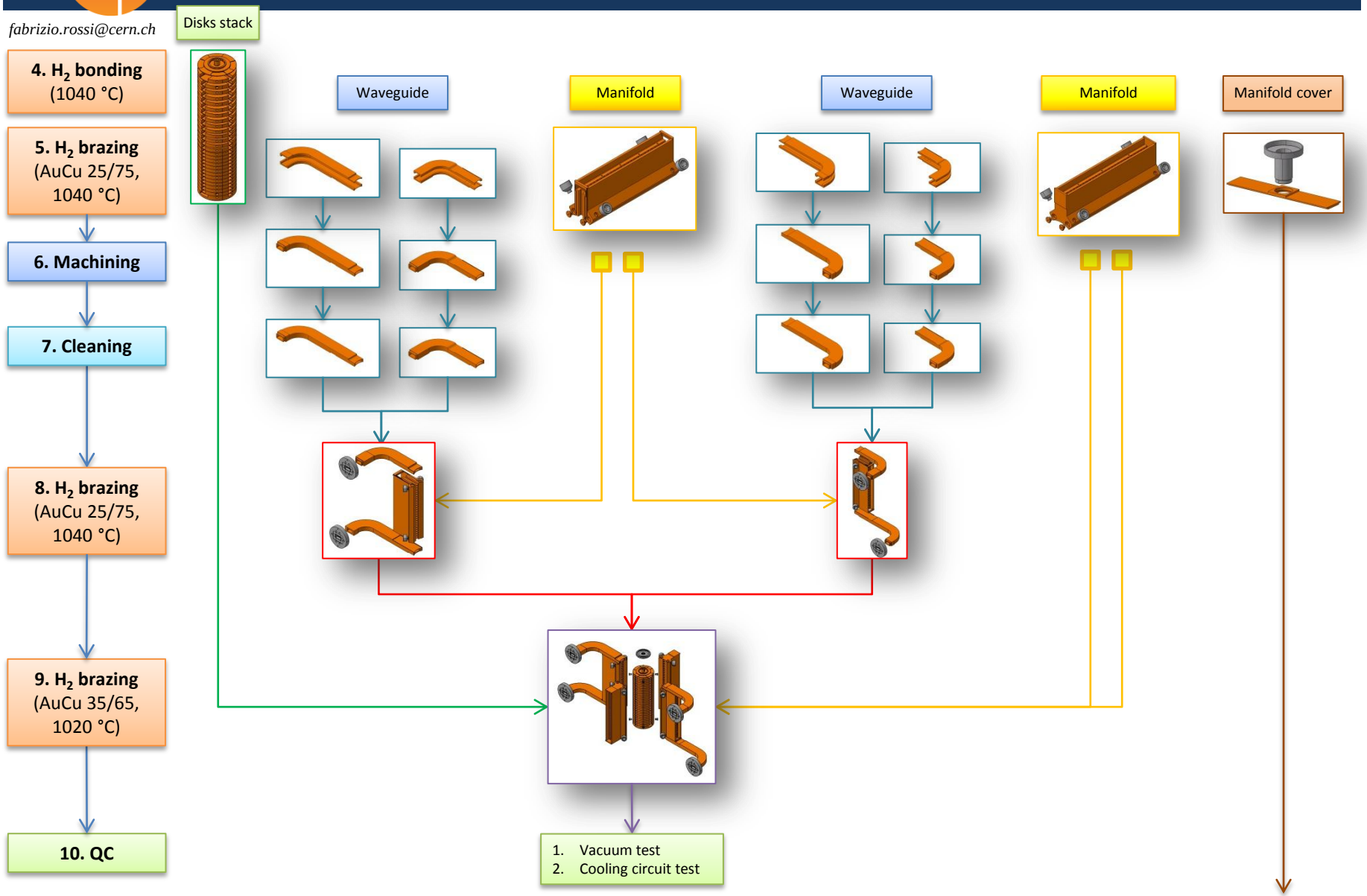

WORKFLOW

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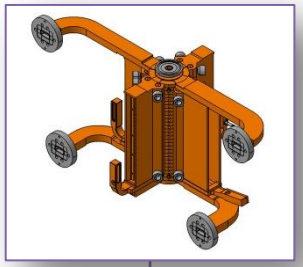

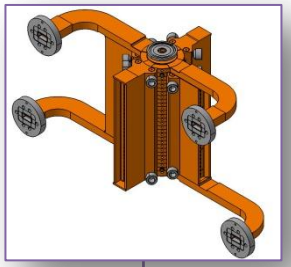

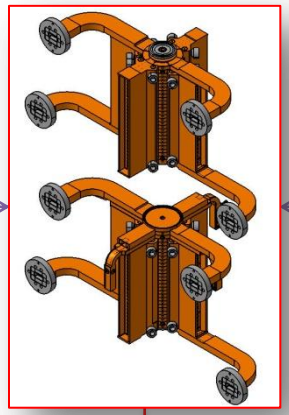

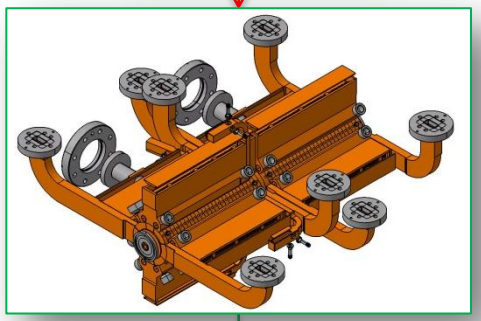

11. H_2 brazing (AuCu 50/50, 980 °C)

12. EBW

13. QC

1. Vacuum test

ASSEMBLY PROCEDURE

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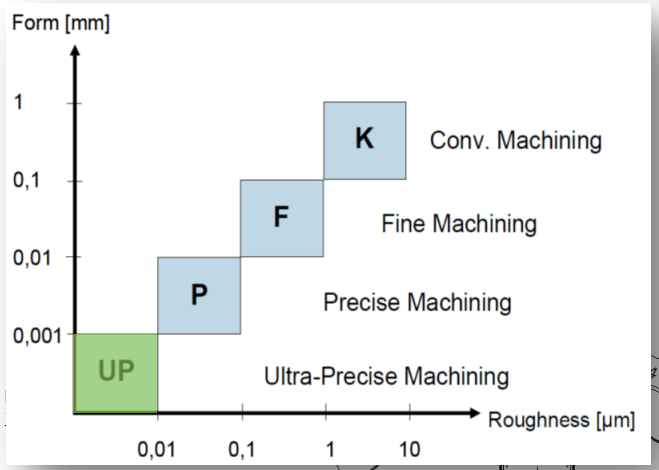
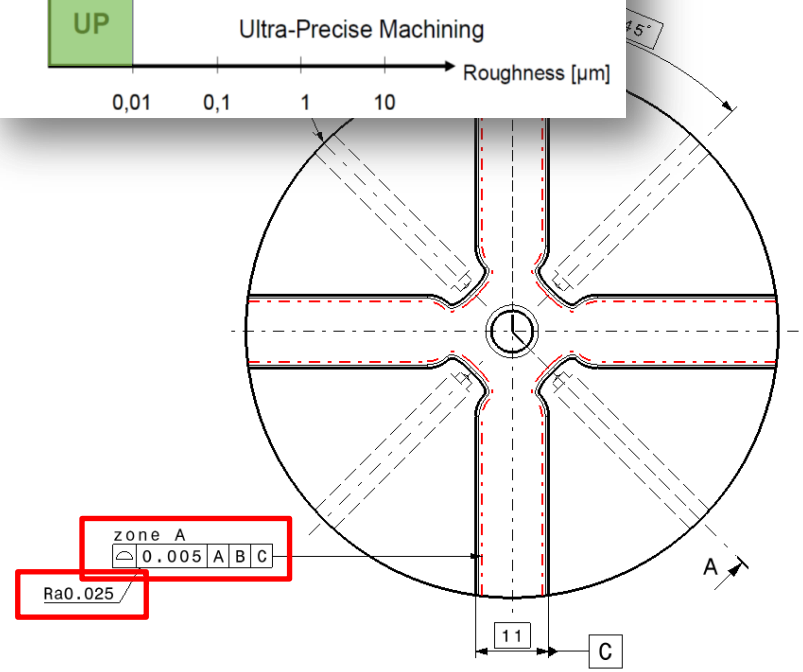
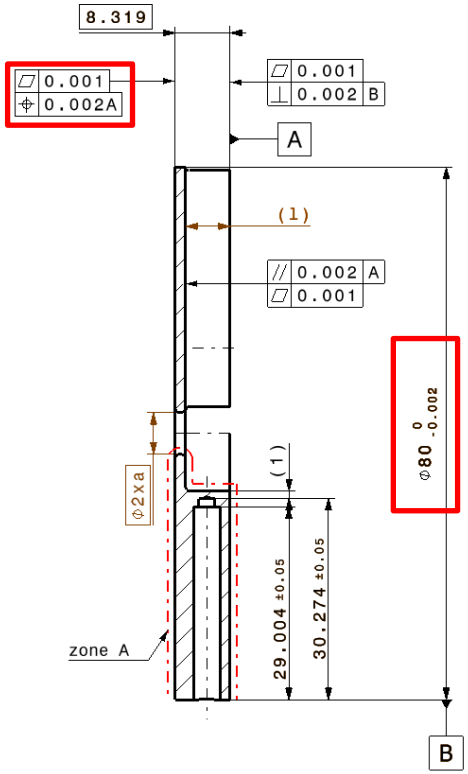
1. MACHINING



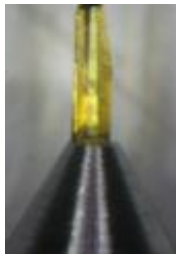
CLIC's requirements
shape accuracy: ± 2.5 µm
roughness Ra: 0.025 µm





DIAMOND TOOLS

- Low coefficient of friction and smoothness
- High thermal conductivity
- Low compressibility
- Low thermal expansion
- Dimensional stability
- About 7 tools are necessary to machine each disk



Hybrid turn/mill machine

ASSEMBLY PROCEDURE

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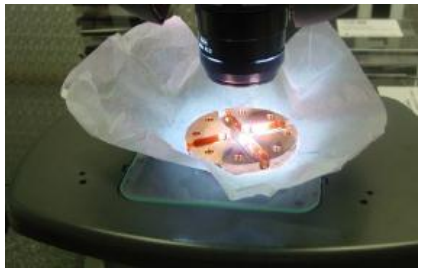
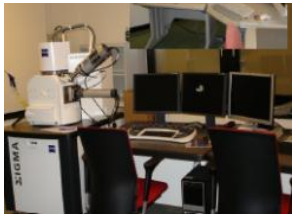
2. QUALITY CONTROL

Inlet inspection



- The inspection takes place in specific room, with all the important issues (clean air, gloves, shoes with gloves, specific glasses and specific machines), in order to check the surface for scratches, dents, pits, cracks. The pieces are also organized in photo archives.
- If parts are not clean enough, cleaning procedure should be done again. If parts are not clean, measurement can't be done because any oil or dust could have an influence on measurement machines.

SEM analysis



- Identify the machining quality (machining marks, burrs) and the general surface quality (contaminations, handling marks, faceting) before operation at high power.
- Characterize the surface (craters, smoothening, waves, peaks, projections, oxidation).

Dimensional control

CERN workshop metrology laboratory

- Class 1 according to VDE/VDI 2627 standard
- Reference temperature: 20 °C
- Temperature gradients: 0.2 K/hour, 0.4 K/day, 0.1 K/meter
- Conditioner with high accuracy of temperature and humidity control (± 0.5 K)
- Filters needed to prevent dust in the dimensional control room
- Vibrations control

New Leitz PMM-C Infinity

- Dimensional control of disks
- Accuracy: ±(0.3 + L/1000) µm
- Pieces up to 1.2 m
- Probe head has adjustable force (0.02-0.26 N)

VEECO

- Roughness and flatness measurements
- Uses white light, lens and CCD camera
- Two hours to measure ∅80 mm disk and two hours to process the images

ASSEMBLY PROCEDURE

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3. CLEANING (FOR BONDING)

1. Unpacking, visual inspection, fixing of the support clip

2. **Degreasing with solvents Topklean MC 20A and Promosolv 71IPA**
   This treatment is repeated twice if there are more than two blind holes. After the first degreasing the piece is removed from the basket and it put onto tissue paper. The support clip is removed and is then inserted into the other holes. The disk is placed in the basket and is degreased for the second time.



3. Removal of the support clip, drying the blind holes with nitrogen, packaging with tissue paper for transport to a different area.
4. Unpacking. If there are any blind threaded holes, these have screws inserted to prevent acid ingression. A hook is then fixed to the screw.

5. **Degreasing with detergent NGL 17.40 spec. ALU III and ultrasounds**
   - Concentration: 10 g/l
   - Temperature: 50 °C
   - Time: 10 – 15 minutes

6. Rising with water jet and by immersion.

7. **Pickling (deoxidation) with hydrochloric acid.**
   - Concentration: 50 %
   - Temperature: room
   - Time: ~ 1 minute

8. Rising with water jet and by immersion.

9. **Etching with SLAC solution**
   - Concentration:
     - phosphoric acid: 70 %
     - nitric acid: 23.3 %
     - acetic glacial acid: 6.6 %
     - hydrochloric acid: 0.49 %
   - Temperature: room
   - Time:
     - 5 seconds for turning (etching of about 0.6 µm)
     - 30 seconds for turning and milling

10. Rising with water jet
11. Immersion in demineralised water, removal of the screws, rinsing of the holes using a syringe and fixing of the support clip and the hook
12. Final rinsing with demineralised water and ultrasounds, followed by rinsing with ethylic alcohol and ultrasounds
    - Temperature : 30 °C
    - Time : ~ 1 minute
13. Drying with nitrogen
14. Drying in an oven
    - Temperature: 60 °C
    - Time: ~ 5 minutes
15. Drying with nitrogen
16. Packaging with tissue paper

ASSEMBLY PROCEDURE

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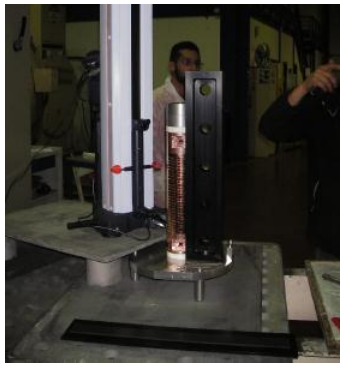
4. H_2 DIFFUSION BONDING (1040 °C)

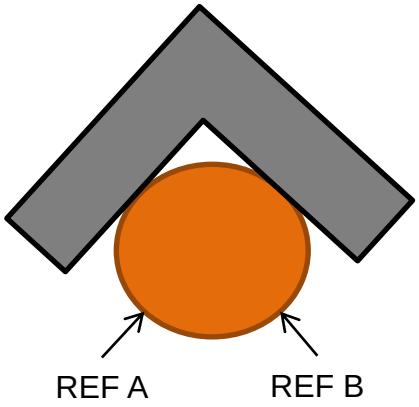
PRE-ASSEMBLY

STRAIGTHNESS MEASUREMENTS



Mitutoyo Linear Height LH-600
Measuring range: 0-972 mm
Resolution: 0.1 µm
Accuracy: (1.1+0.6L[mm]/600) µm
Measuring force: 1N

- Once the assembly procedure is completed, straightness measurements are performed using the Mitutoyo Linear Height LH-600.
- The measurements are done with the accelerating structure on the V-support and considering two reference lines, called REF A and REF B.
- The measurement is done before and after transport to the oven and they are organized in charts.
- Accuracy of V-shape column: ± 1.5 µm



ASSEMBLY PROCEDURE

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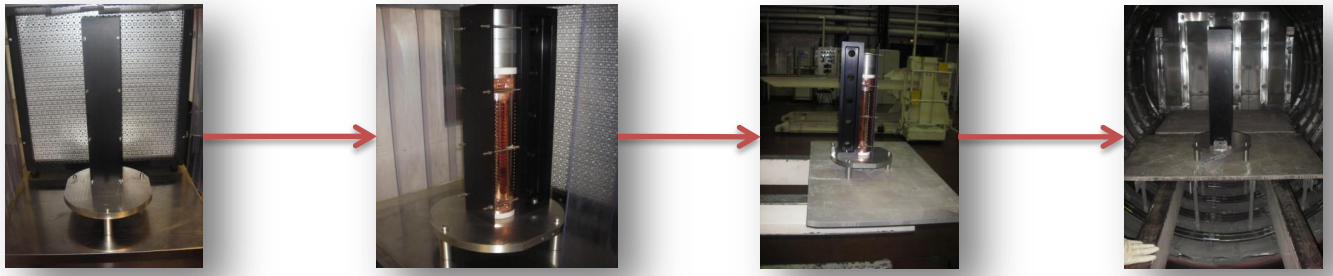
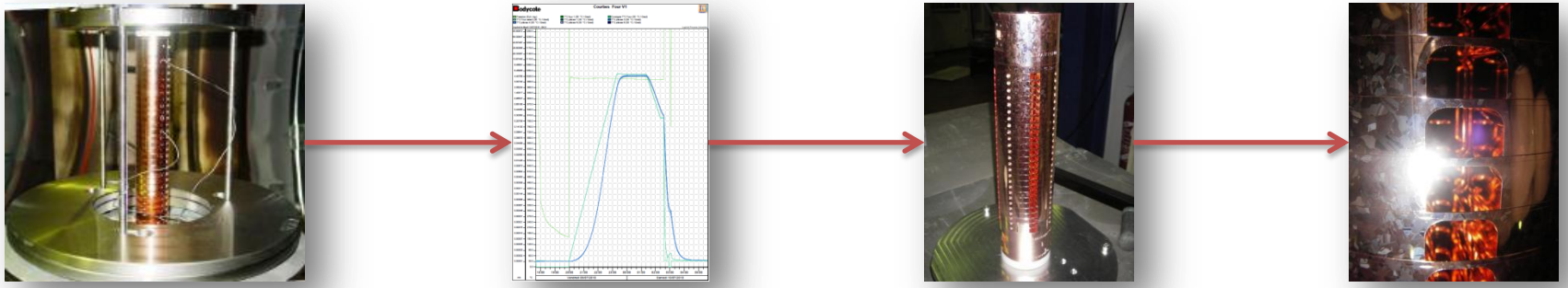
4. H_2 DIFFUSION BONDING (1040 °C)

TRANSPORT TO FURNACE



LOAD APPLICATION



1. Load (0.28 MPa) is applied to the disks stack using the load device and thermocouples are mounted to measure the temperature history during the heat treatment .

2. Bonding inside the furnace:
   - atmosphere: H_2
   - temperature: 1040 °C

Before each bonding cycle, a outgassing cycle is performed.

3. Bonded disks stack

4. Particular of the grains aspect after the heat treatment. Grains size order of few millimeters.

ASSEMBLY PROCEDURE

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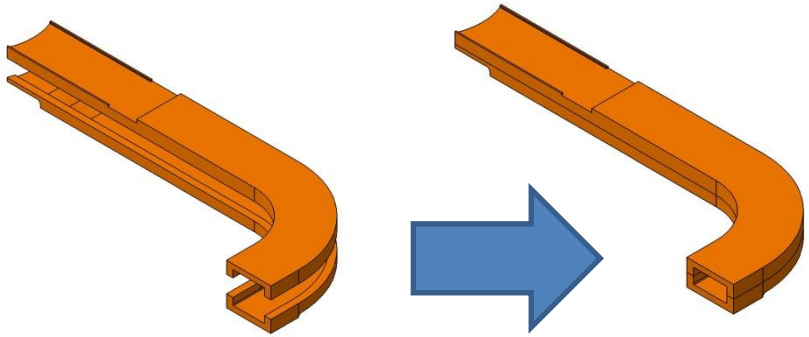
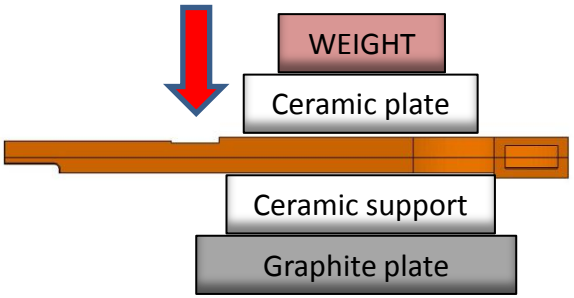
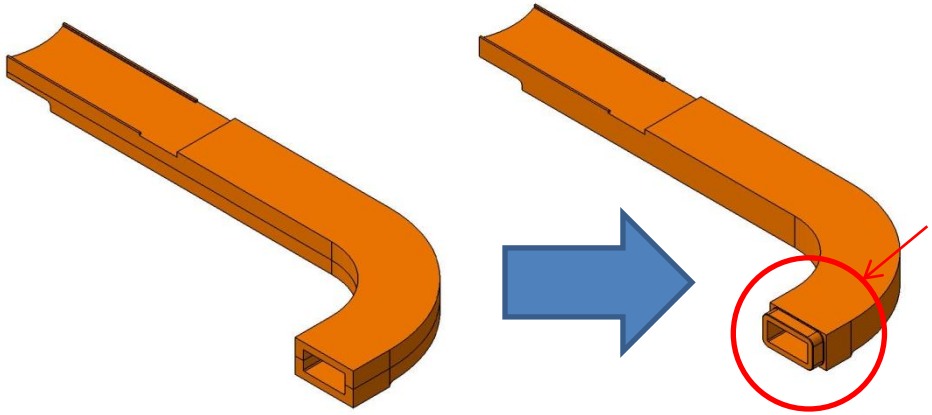
5. H_2 BRAZING (Au/Cu 25/75, 1040 °C)



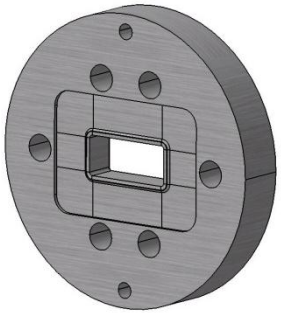
Brazing wire groove
(Au/Cu 25/75)



6. MACHINING



- Waveguides are machined with reference to RF flanges dimensions, in order to achieve a clearance of 0.02-0.06 mm between the two surfaces where the brazing alloy will flow and create the joint.



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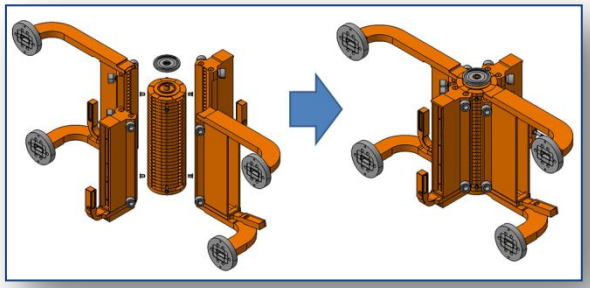
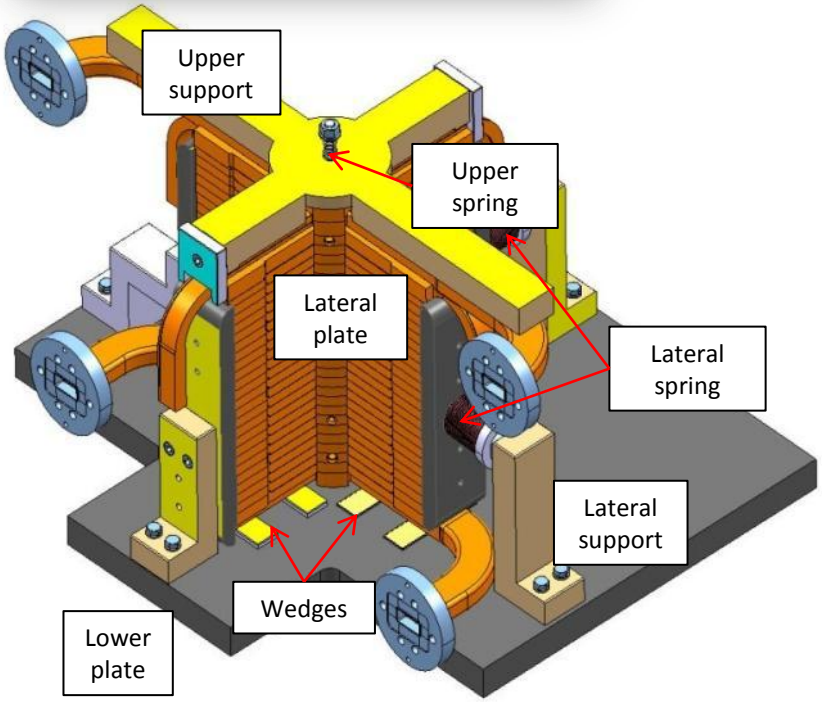
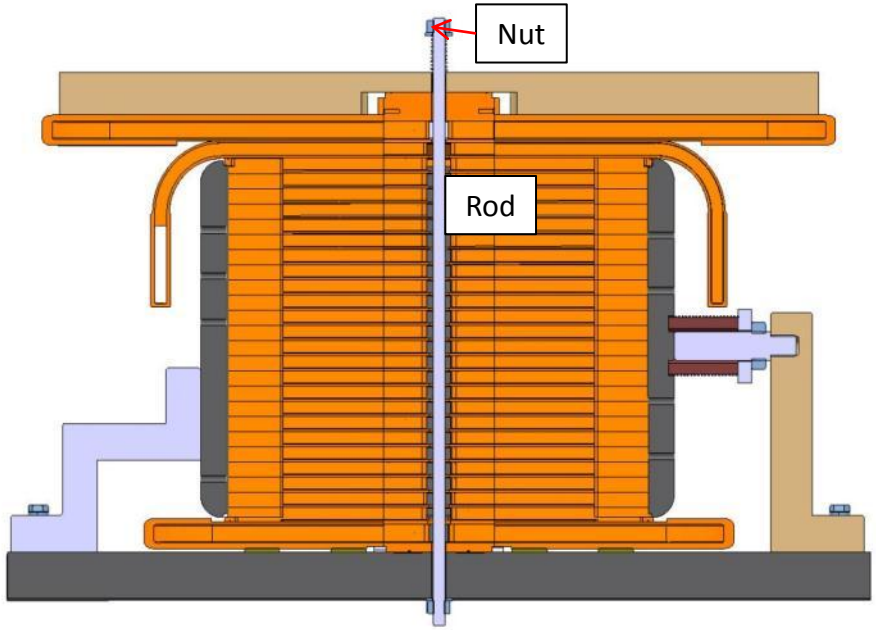
9. H_2 BRAZING (Au/Cu 35/65, 1020 °C)



- Upper spring (graphite): apply a vertical force on the manifolds through the upper support and allow thermal expansion of the assembly during the brazing cycle.
- Rod (stainless steel): connect upper support and lower plate.
- Lower plate (graphite): support the assembly during alignment operations and brazing cycle.
- Wedges (ceramic): allow small adjustment of manifolds in the vertical direction.
- Lateral springs (graphite): apply an horizontal force to the manifolds through the lateral plates and allow thermal expansion of the assembly during the brazing cycle.
- Lateral supports (stainless steel): support the springs.





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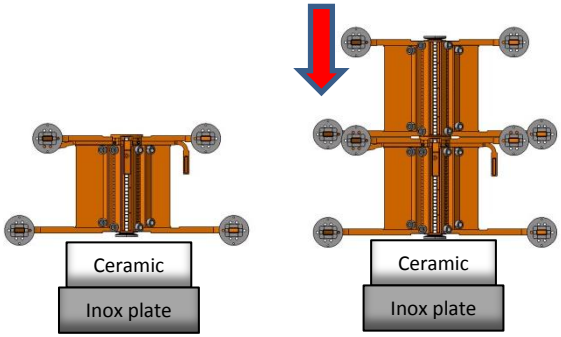
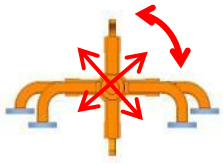
10. H_2 BRAZING (Au/Cu 50/50, 980 °C)

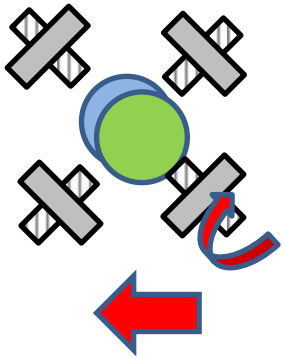


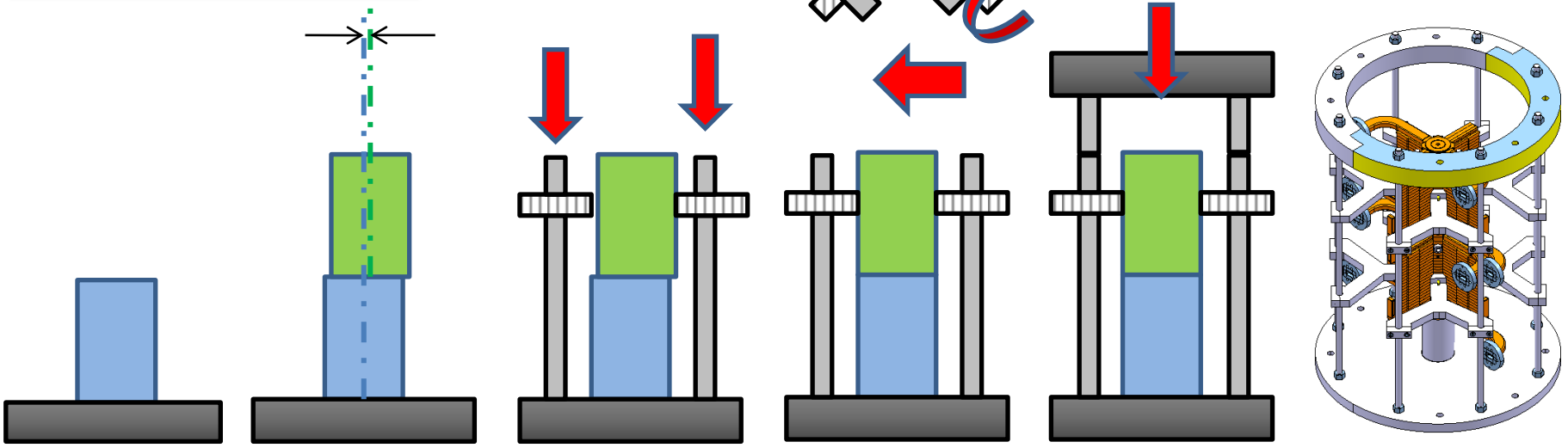


3 DOF

Mitutoyo Linear Height LH-600

TOOLING





1st structure | *2nd structure and measurement* | *Auxiliary frame* | *Alignment* | *Tooling ready for transport to furnace*

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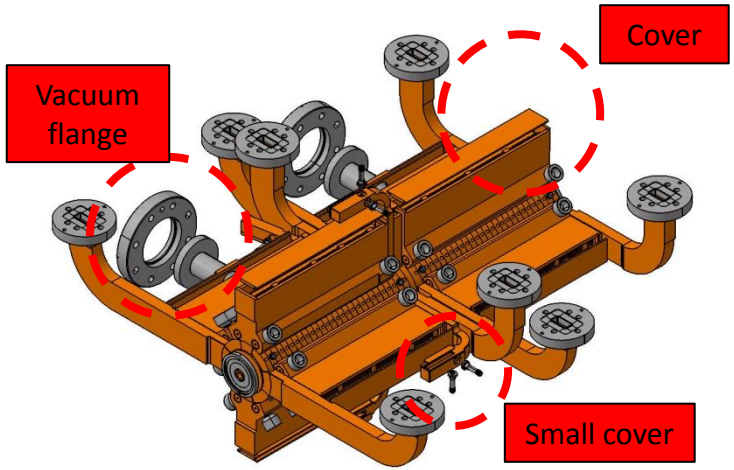
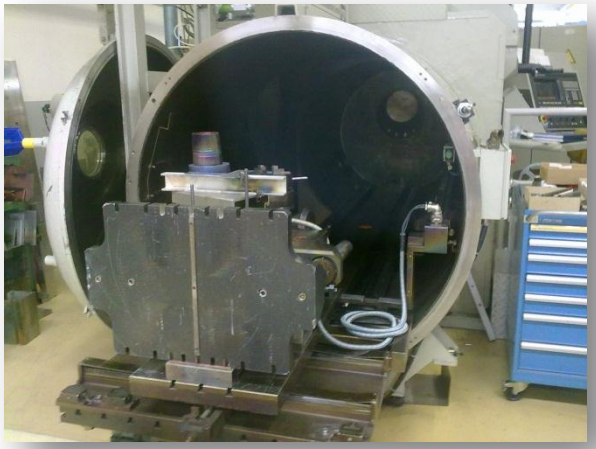
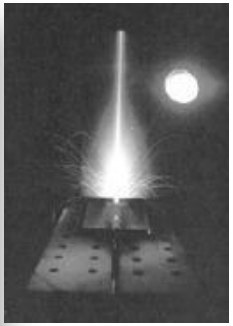
12. EBW

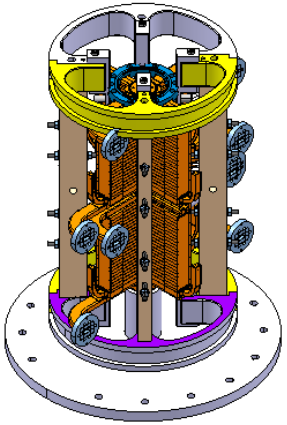


TOOLING

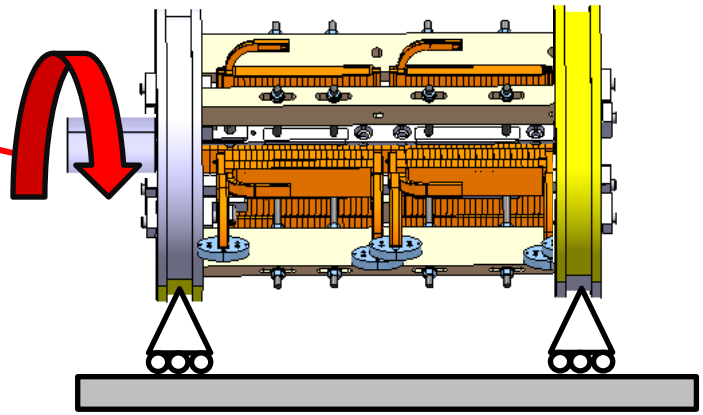




EBW machine
(CERN workshop)



EBW machine chunk



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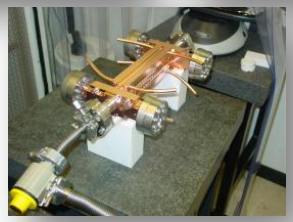
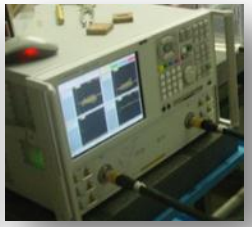
13. QUALITY CONTROL

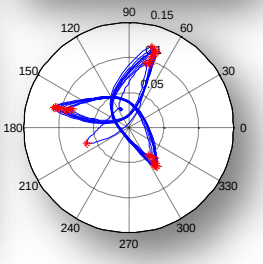
Vacuum test

- Leak detector and Helium are used for vacuum tests.
- Helium is pumped around the accelereting structure and if a leak is present is detected by the machine.



14. RF CHECK AND TUNING





- After bonding and brazing processes, accelerating structures must be tuned to compensate the different assembly errors.
- Tuning is performed modifying by plastic deformation the cell walls and checking, at the same time, the results of this operation by means of a network analyser.
- Plastic deformation is achieved by pushing or pull the tuning studs brazed in the accelerating structure.

ASSEMBLY PROCEDURE

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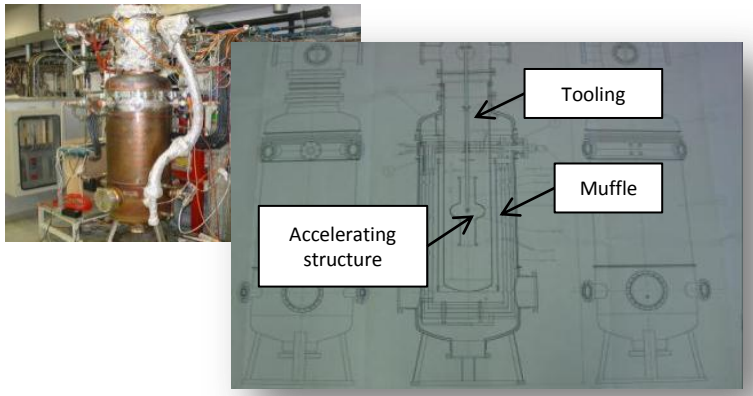
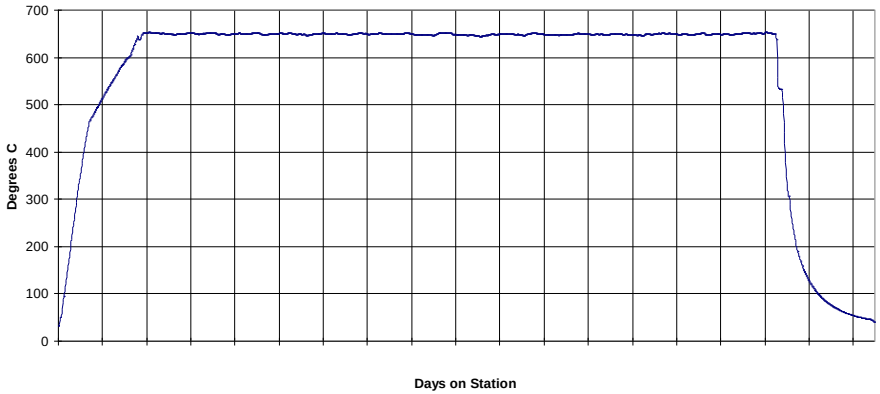
15. VACUUM BAKING (650 °C, 10 days)





16. CONDITIONING

- The accelerating structure is positioned inside a container with a protective atmosphere (N_2) to prevent copper oxidation.

CONCLUSIONS

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- Requirements for disks machining are very strict (shape accuracy: ± 2.5 µm, roughness Ra: 0.025 µm)
- These requirements should be preserved after each step of the assembly procedure
- Toolings are necessary to fulfill these accuracy needs during the different steps
- Nevertheless, assembly errors are present at the end and the final RF tuning of the accelerating structure is performed to compensate them.

⇒ Main critical issues:

  - Alignment of manifolds and AS for brazing
  - Residual deformations after heat treatments at ~ 1000 °C

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Mectalent

- Manufacturing of toolings for brazing and EBW. For what regards brazing, a close collaboration with Loval is required.

- Timetable: April 2012.

Loval

- Furnaces will be adapted to perform H_2 brazing at 25 mbar. In the meantime, brazing tests can be done for those components for which H_2 atmosphere is not mandatory (like cooling circuits, waveguides, WFM).

- Timetable: mid of 2012

THANKS

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