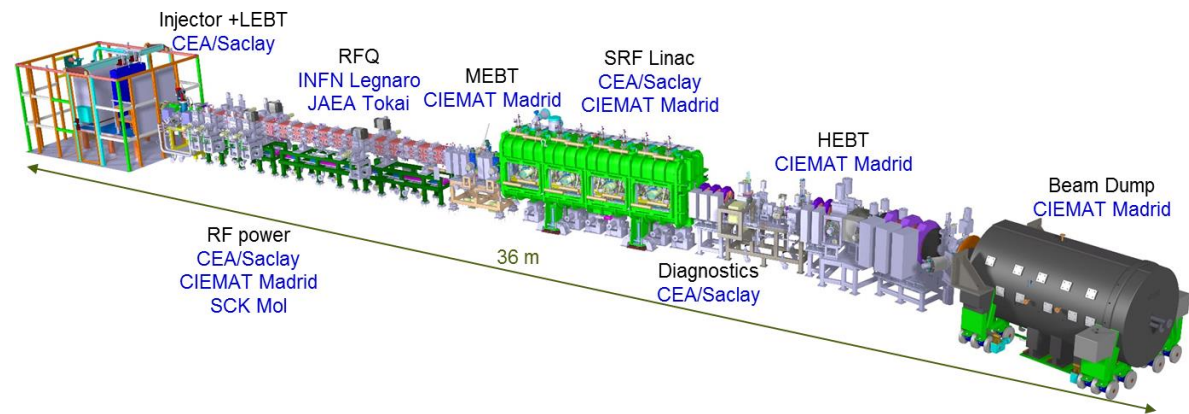


DE LA RECHERCHE À L'INDUSTRIE



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ASSEMBLY OF THE IFMIF CRYOMODULE



Janic Chambrillon

On behalf of the SRF-Linac Team

TTC Meeting - June 5th – 8th, Saclay

The IFMIF cavity string

Test and trial on cavity string elements

BPM's buttons

Trial assembly outside the cleanroom

Trial assembly in cleanroom ISO5

Test on the needle bearings

Cavity coupler assembly

Cavity tuner

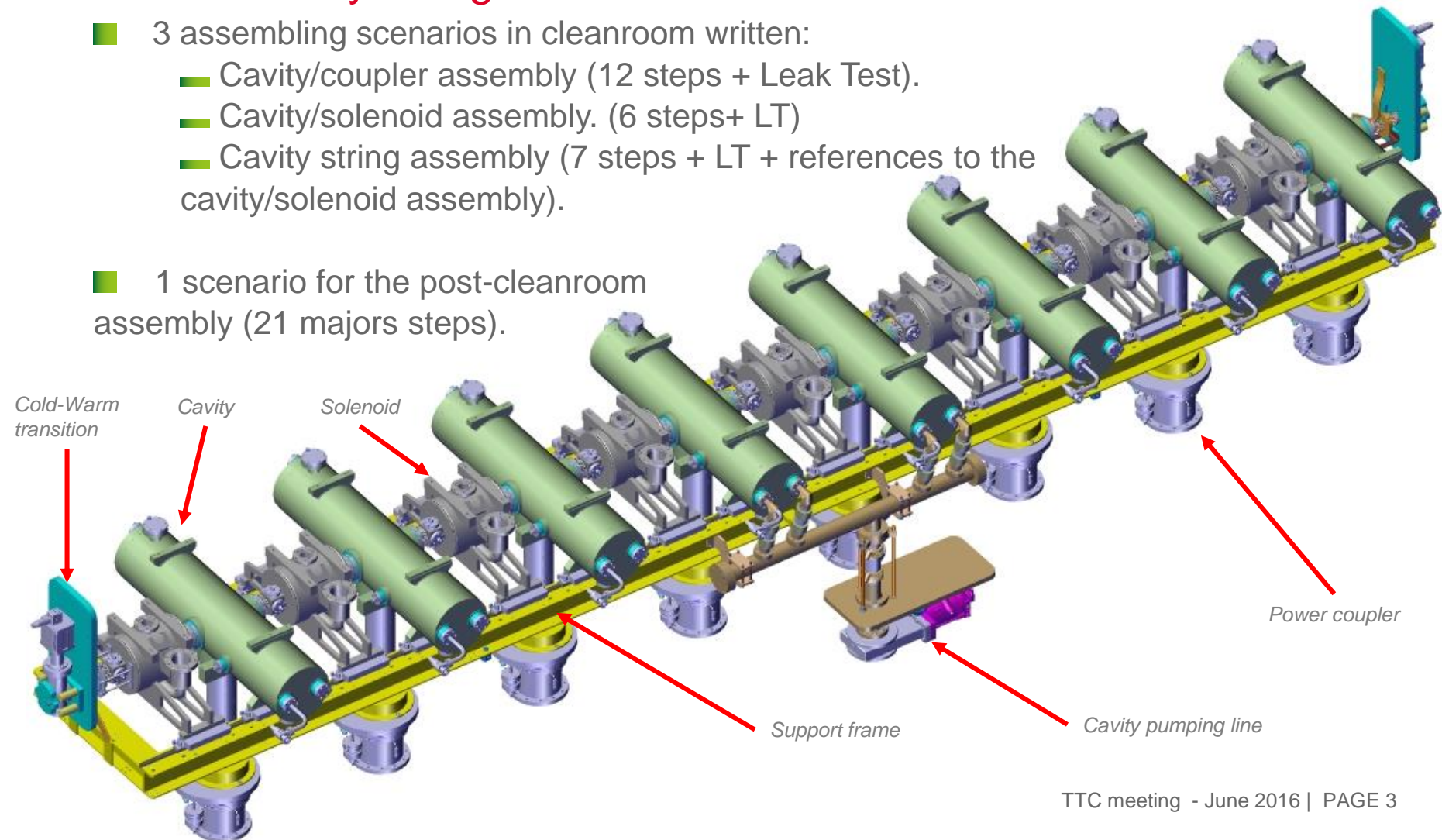
Cryomodule assembly

Conclusion

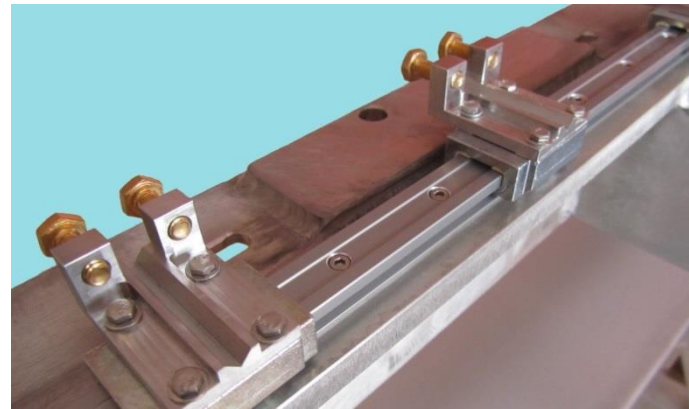
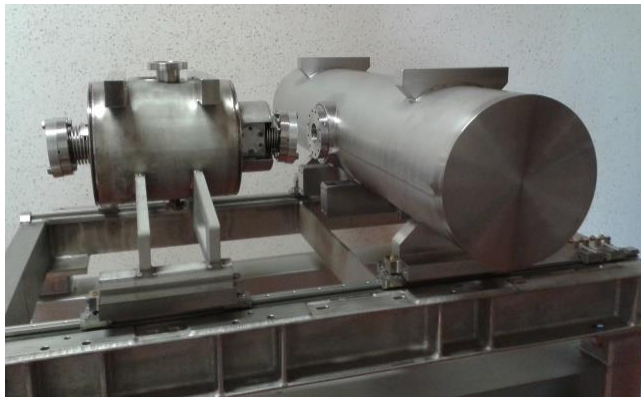
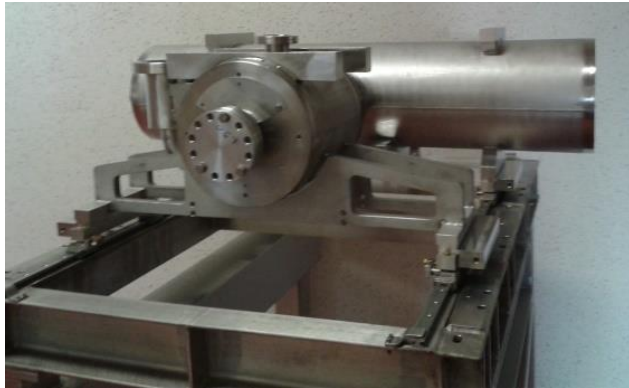
Cavity string

- 3 assembling scenarios in cleanroom written:
 - Cavity/coupler assembly (12 steps + Leak Test).
 - Cavity/solenoid assembly. (6 steps+ LT)
 - Cavity string assembly (7 steps + LT + references to the cavity/solenoid assembly).

- 1 scenario for the post-cleanroom assembly (21 majors steps).



- To validate and / or improve the clean room assembly procedure and the associated tools a test bench as realistic as possible was needed.
- A frame, a little bit bigger than one eighth of the final support and equipped with linear guides and the positioning system, was manufactured.
- Because of the late delivery of the final elements, a dummy cavity, a dummy solenoid and a dummy coupler were manufactured.



Auxiliary linear guide assembled on the support frame with two carriages equipped with positioning adjustment elements

BPM's buttons of solenoid packages

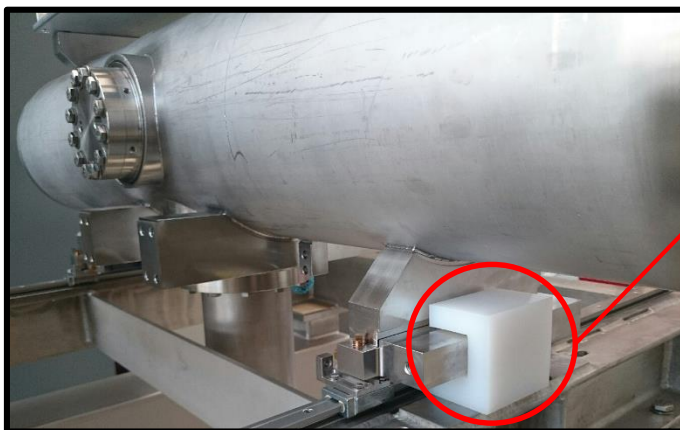
- Cleaning test done in cleanroom ISO class 5.
- Ultra sonic bath + Ultra Pure Water (UPW) rinsing.
- Blowing with N₂, and particle counting.
⇒no particle emission after 1 min.



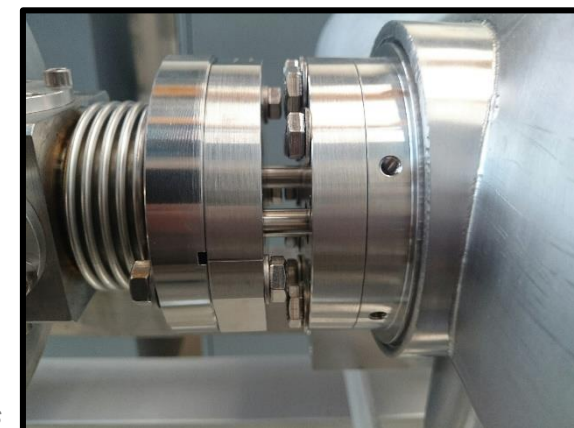
Checking the cleanliness

Trial Assembly outside the cleanroom

- Test the assembly procedure of a solenoid and a cavity equipped with its coupler.
- Tests were carried out with mock-ups.
- Led to some improvements (new adjustment screws, C-templates, carriages without slack)



Calibrated gauges are used to with the C-template when positioning



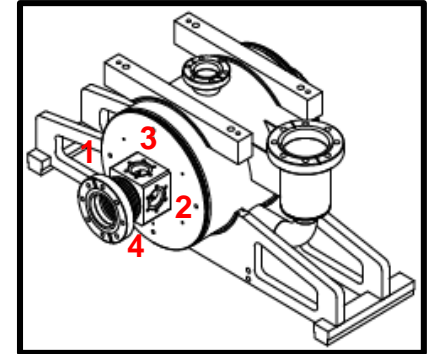
Alignment flanges

Positioning of the cavity with the C-template

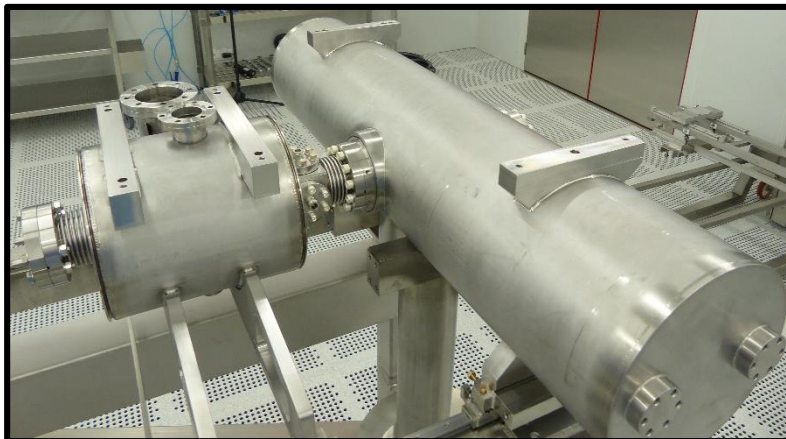
Trial assembly in cleanroom ISO 5

- Assembly of the button on the BPM.
 - Test an assembly sequence and configuration.
 - Despite there was no High Pressure Rinsing done, the monitoring showed good results.
 - To be confirmed on a real solenoid after a HPR.

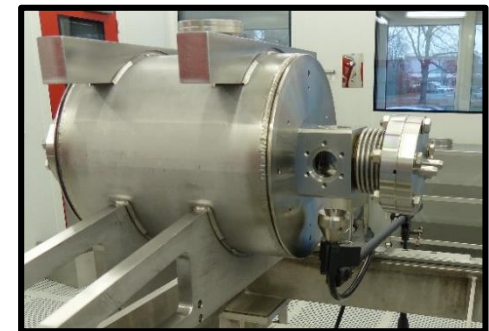
- Connection between the solenoid and the cavity (mock-ups).
 - Training outside of the cleanroom was very beneficial .
 - ⇒ Quicker positioning and assembly of the elements.
 - The assembly test bench could be use to train the contractor in charge of the assembly.



Assembly sequence of the buttons



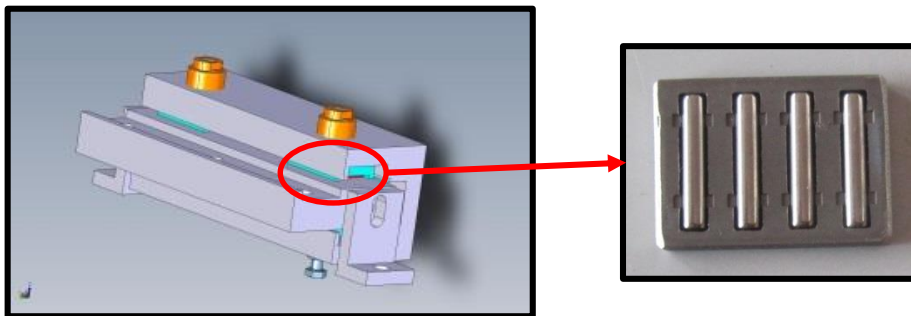
Cavity and solenoid connected



Particle monitoring during assembly of the buttons

Needle bearings and C-shape elements

- Similar to the one used on X-FEL cryomodule, they allow to manage the thermal contraction of the support frame with respect to the cavity string



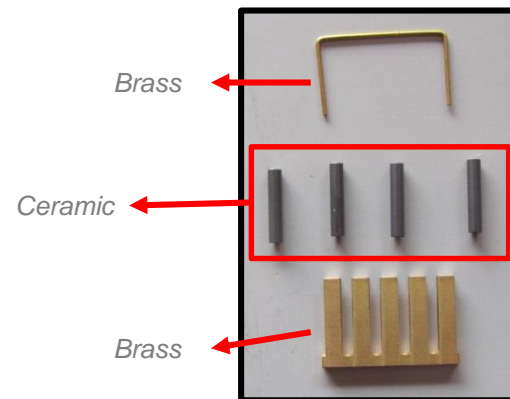
- Original bearings are subject to magnetization



Bearing cage and needles magnetized

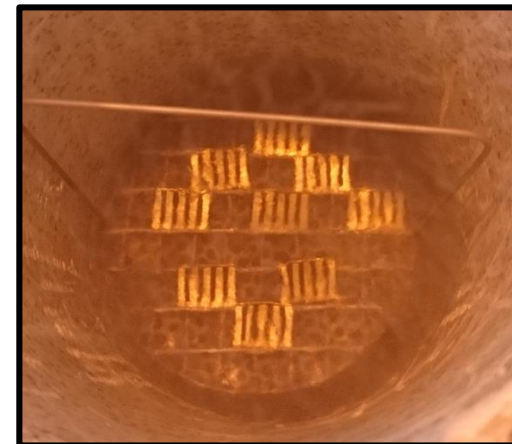
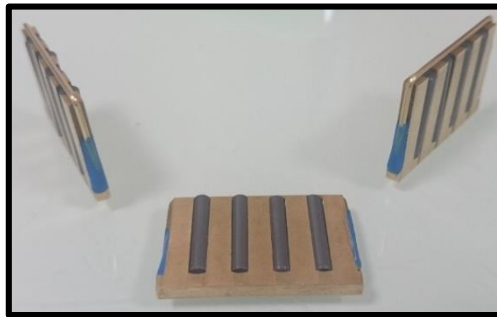
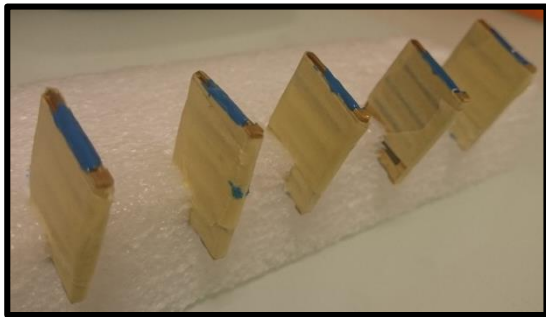


- CEA design new bearing without ferromagnetic materials

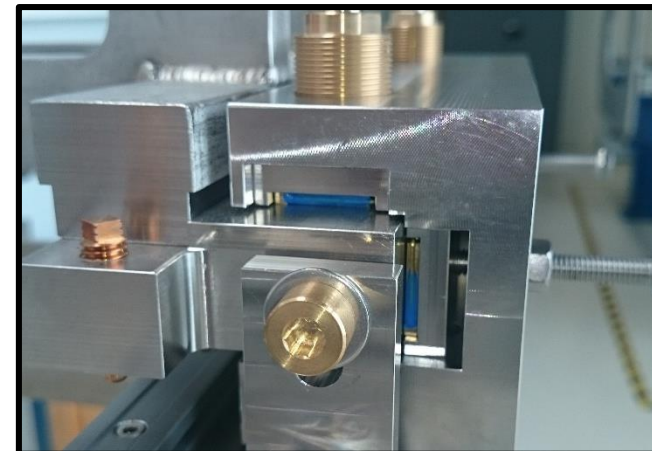
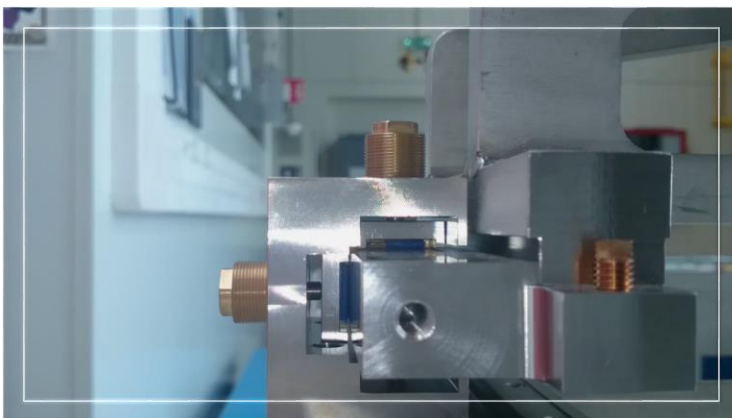


(see TTC 2014: <https://indico.in2p3.fr/event/10347/session/8/contribution/35>)

- The cage of the bearing was glued with Stycast®, followed by 3 thermal shocks in liquid N₂ (~77 k).



- No defect after the thermal shocks.
- The bearings were tested on the test bench and validated.



Test on the assembly tooling

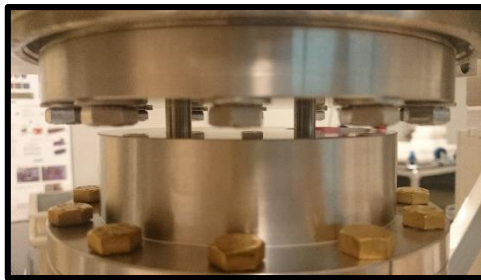
- Currently tested with the mock-ups.
- Test on going with threaded shafts replacing bolts.



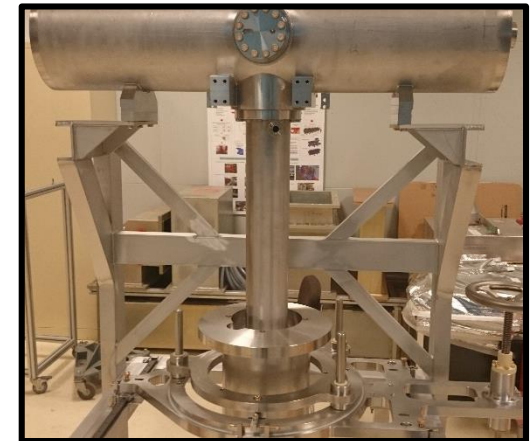
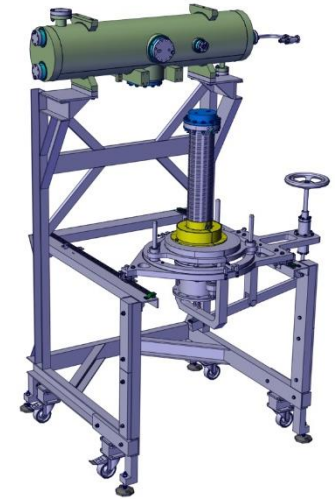
Level adjustment of the cavity on the tooling



Coupler ready for the fine alignment with cavity



Alignment flanges in correct position

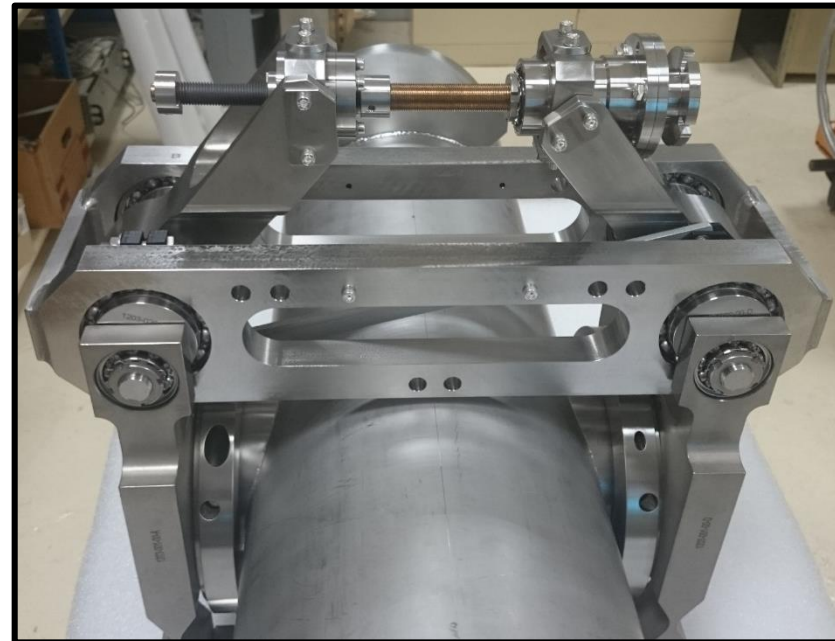
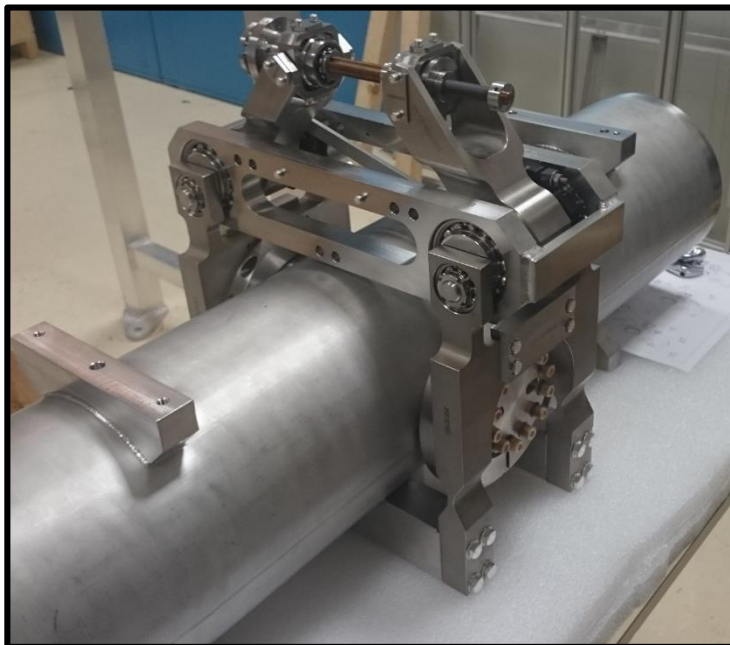


Assembly done

- The scenario will be tested in cleanroom in the frame of SatHori (test stand for a cavity/coupler assembly).
- If validated, this tool could be used for the assembly of the cavity / coupler assemblies of the cavity string.

Assembly of the first tuner

- Checking of the motor stroke and command.
- Trial assembly on the cavity mock-up.



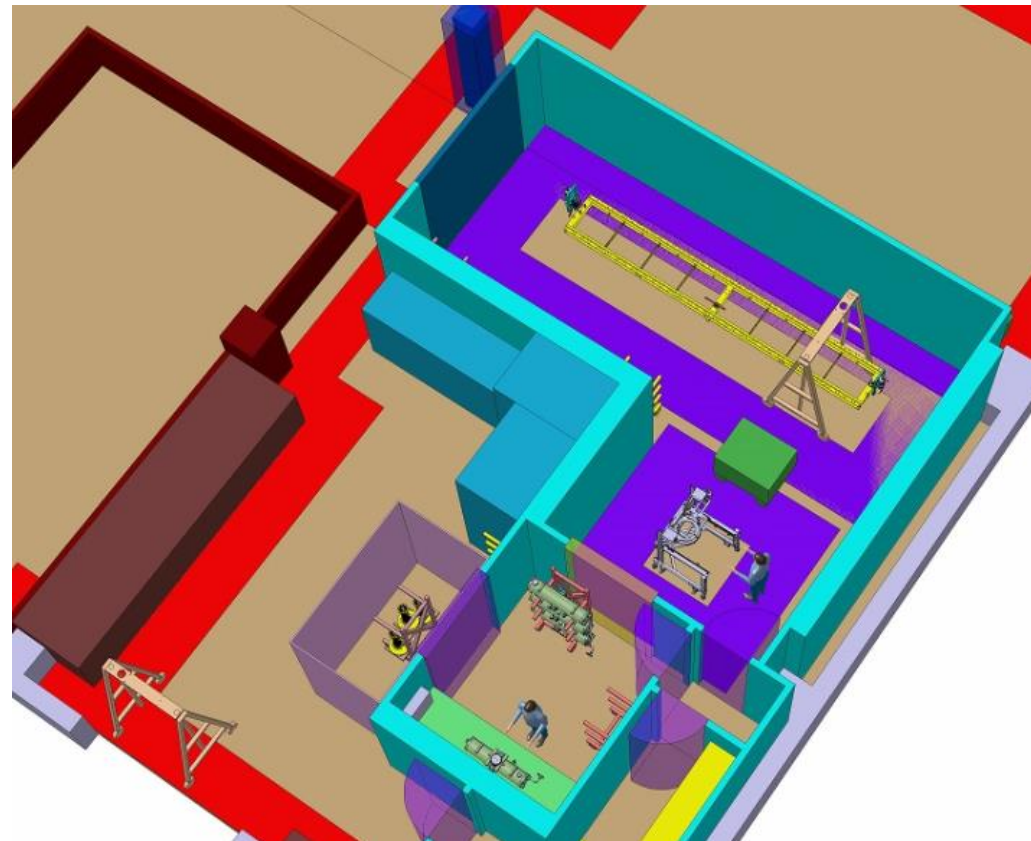
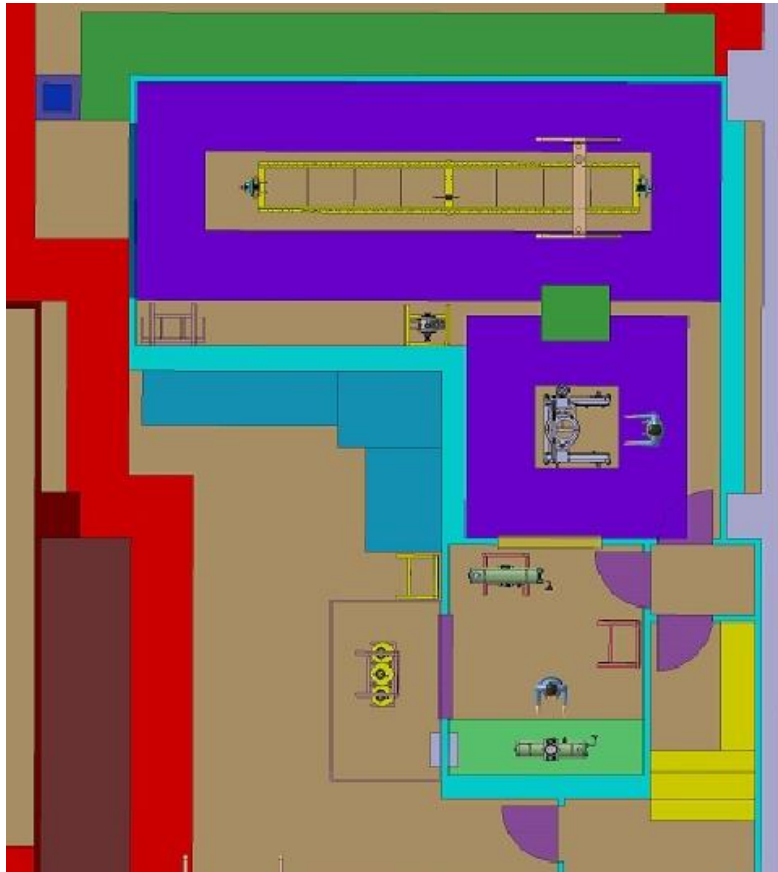
First cavity tuner assembled on the cavity mock-up

Assembly of the cryomodule at Rokkasho

- September 2015: project decision to assemble the cryomodule in Japan, on the QST site at Rokkasho.
- A clean room will be built by QST.
- F4E will be in charge of the assembly (sub-contracted), CEA will provide technical assistance.
- Cavities, couplers and solenoids will be validated in Europe, packed in double-sealed bags in ISO 5 before shipment to Japan.
- Cryomodule components (vacuum vessel, thermal shield, support frame, magnetic shield, helium circuitry ...) are being manufactured in Europe.



- QST manages the installation of the clean room and associated ancillary equipment.
- F4E and CEA provide technical input for the definition of the clean room requirements, including ancillary requirements.



cea ASSEMBLY STORYBOARDS



- Based on the assembly tests performed at Saclay, CEA has written assembly storyboards.
- Will be included as annexes in the technical specifications for the assembly contract (F4E responsibilities).

The storyboard pages contain the following content:

- ASSEMBLY OF THE IFMIF CRYOMODULE: POST CLEAN ROOM SCENARIO**: Overview page with logos for CEA, Irfu, and IFMIF.
- CLIQUEZ POUR AJOUTER UN TITRE**: Multiple pages showing assembly steps for adding a title, including instructions like "place the plate used to check the flatness on three carriages" and "Turn clockwise / anti-clockwise the four screws with square head and ball end to move up / down the four supports of the cavity".
- FLATNESS ADJUSTMENT - 2**: Page with instructions: "Turn clockwise / anti-clockwise the four screws with square head and ball end to move up / down the four supports of the cavity until the flatness is correct".
- PROCEDURE FOR THE POSITIONING AND THE ASSEMBLY OF A CAVITY AND A SOLENOID**: Overview page with logos for CEA, Irfu, and IFMIF.
- INTRODUCTION: THE FRAME**: Page describing the frame of the IFMIF cryomodules, including a list of requirements like "Frame made of stainless steels" and "Flatness requirement: 0.1 mm".
- REFERENCE SCENARIO**: A flowchart showing the assembly process from "Check the components" to "Check the position of the cavity".
- INSERTION OF THE COLD MASS INSIDE THE VACUUM TANK: PRINCIPLE**: Page explaining the two-step insertion process: "Horizontal sliding of the frame" and "Vertical motion of the frame".
- ASSEMBLY OF THE CAVITY AND SOLENOID**: Pages showing detailed assembly steps for the cavity and solenoid, including instructions like "Once the solenoid is correctly positioned, approach it to the cavity" and "Step XX: on the upright side (point of view of the beam)".

- Manufacturing the cryomodule components in Europe and assembling it in Japan is challenging.

- Importance of the quality control:
 - No workshop available at Rokkasho during the assembly.
 - Strong control during factory acceptance: every tapped hole shall be controlled on every component.
 - Every possible assembly should be tried before shipping to Japan (ex: magnetic shield in the vacuum vessel).
 - Magnetic hygiene: permeability control on every component close to the cavities.

- To prepare the clean room assembly, CEA performed assembly tests using mock-ups. These one could be used by the assembly contractor to train the operators.

Thank you
for
your attention

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