Cleanroom assembly of the LIPAc cryomodule

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Introduction

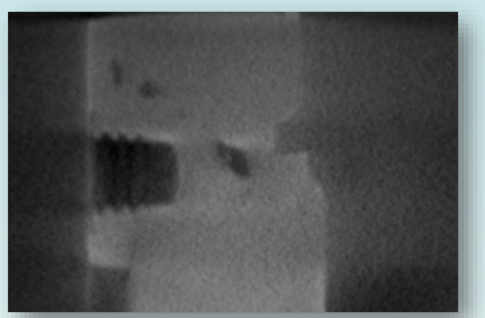
The LIPAc (Linear IFMIF Prototype Accelerator) is the technical demonstrator for the production and acceleration of a deuteron beam that will be used for neutron production by nuclear stripping reaction on a liquid lithium target. Since its first beam in 2014, the LIPAc continue its tests and assembly. The next phase is the addition of the superconducting Linac. The assembly of the SRF Linac started in 2019, but had to be paused due to welding issue on the solenoids. The slow pumping system also needed some improvement to overcome a helium contamination. Two and half years after, the assembly restarted once the travel ban in Japan was lifted. Good progress were done during the first phase of the assembly but new technical issues appeared on different vacuum interfaces as well as some concerns about the solenoid performances. This poster presents the different difficulties, solution and progress of the cleanroom assembly of the SRF Linac.

Superconducting Solenoids Reparation

Different defaults needed to be fixed: rust dots in bellows, oversized seams, surface finish of the welds, one BPM thread leaking in beam tube.

Corrective actions in Spain: grinding followed by pickling and passivation. **BUT** new black marks appeared requiring a new iteration.

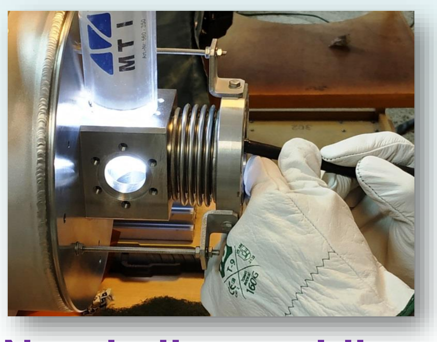
Leaking thread was recharged with welding material but trapped a small gas volume.



Repaired thread with trapped gas volume

Rust dots, oversized seam, black marks, final seam result

Solenoid V06: a leak appeared on the welding seam of a bellow due to overheating. A first attempt to fix it by welding failed. The bellow was finally changed by a new one.

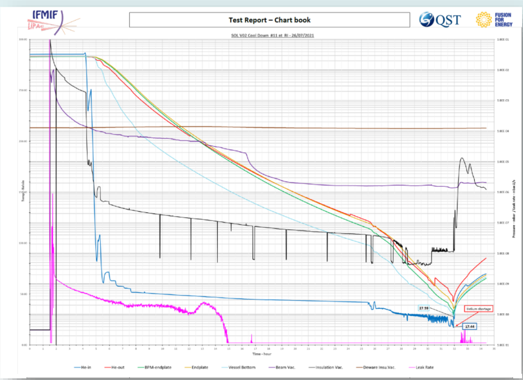


New bellow welding

Solenoid Cold Leak Test

Each solenoids were cold leak tested **in Germany** to check the leak tightness of the helium vessel.

- Small test stand fed with Helium dewar.
- Leak detector suffer from helium contamination.
- Relocation of the leak detector to another room improved the test results.
- 2 solenoids presented leaks approaching the 70 k area => wrong configuration discovered on the current lead interface (O-ring instead of Helicoflex);
- 6 solenoids had to pass one cold test successfully;
- 2 repaired solenoids had to pass 3 cold tests successfully;

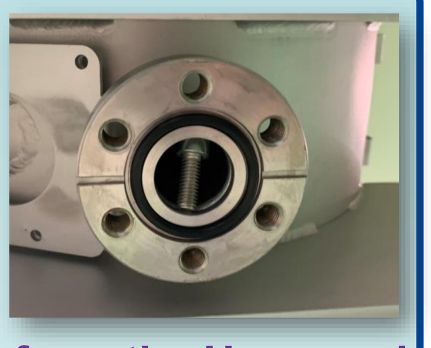


Test chart, He signal in pink

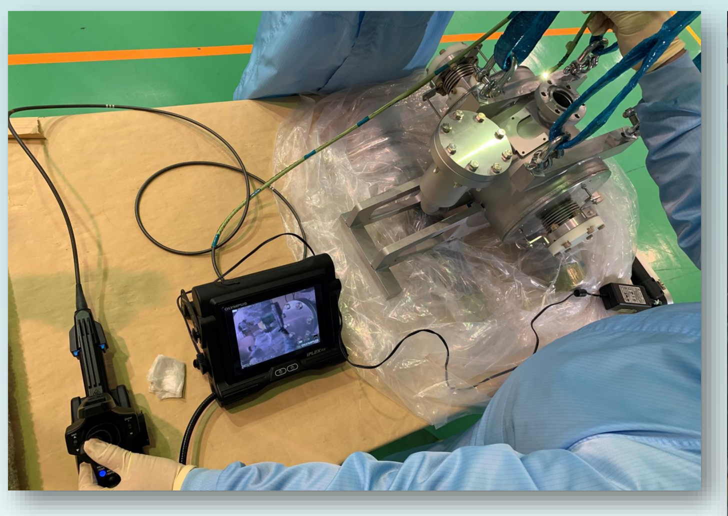
Solenoid on test insert

Solenoid HPR & Tomography

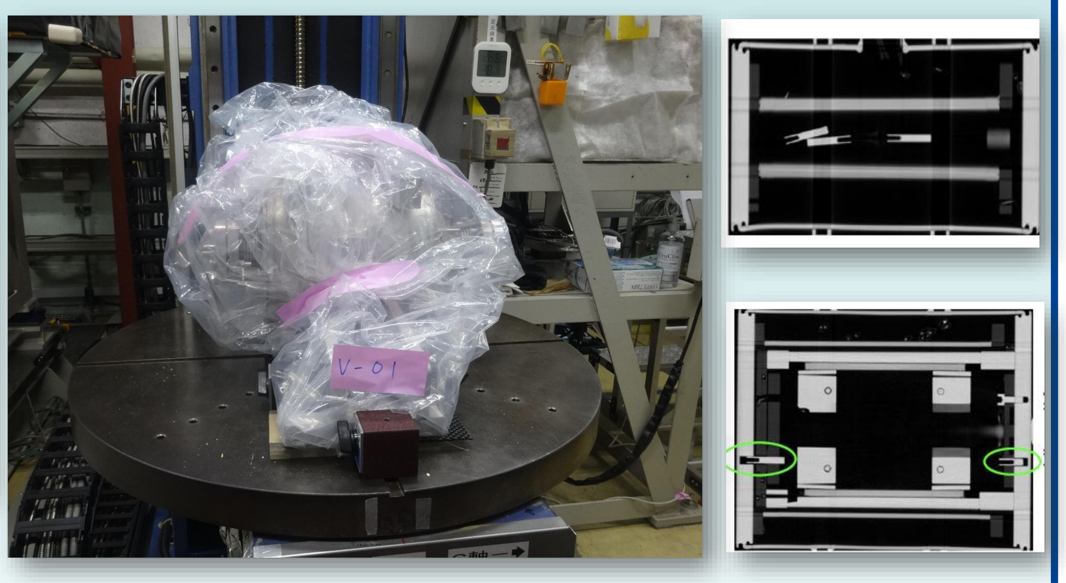
- Solenoid preparation **in Japan** for the cleanroom assembly.
- Ultra Sonic bath followed by High Pressure Rinsing, before BPM pick-up assembly in cleanroom.
- During HPR, a screw was found in a helium vessel.
- A second solenoid presented a rattling sound.
- After an endoscopy the solenoids went all for a tomography.



Screw from the He vessel



Endoscopy in the He vessel



Solenoid tomography with retracted pins

- Tomography showed some solenoids had partially or fully retracted centring pins.
- Some pins were pushed out during the last assembly step of the solenoids.
- Two solenoids possibly critical for beam operation.
- Beam dynamic study done to position each solenoids at best on the beam line and operate in degraded mode if a failure occurs *(see Operational consideration in the LIPAc SRF with solenoid failure mode, T. Ebisawa, SRF2023)*

Slow Pumping System (SPS) Improvement

The SPS seats next to the air exhaust of the cleanroom. Some vacuum connections used O-ring gaskets. During leak tests in cleanroom, the O-rings diffused helium in the system resulting in a strong Helium background.

The new system is now using only metal gasket connection (VCR or CF) and shows no more high Helium background.

Cleanroom Assembly

- 3 Cavity/Coupler already assembled in 2019.
- Cavities were closed with diamond shape gaskets on coupler port after RF vertical test. Final assembly is with Helicoflex gasket. Aluminium fillings found in some sealing grooves.
- Cavity/Coupler assembly went smoothly. 2 cavities needed 2 attempts to correct a small leak ⇒ Al filling from previous gasket suspected.
- Cavities were N_2 flush during assembly.
- 7 out of 8 solenoids were inspected and leak tested successfully.
- All cavities and a couple of solenoids sit now on the support frame and were pre-aligned for the string assembly.

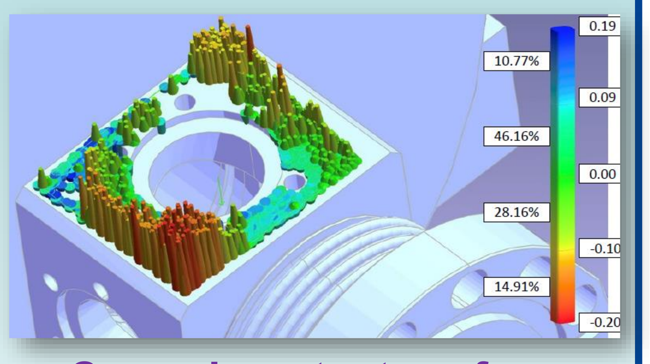
Cavity/Coupler Assembly Courtesy of RI GmbH

All 8 SRF cavities on the support frame

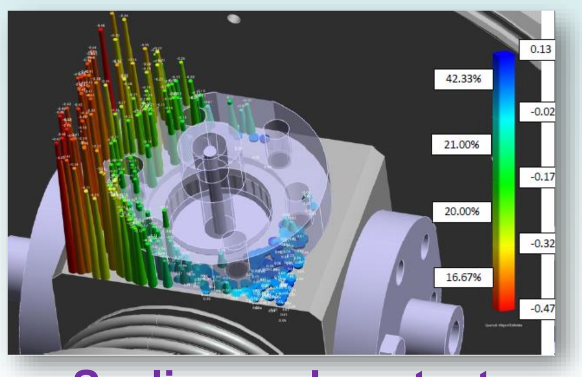
Solenoid V06 BPM Issue

- One pick-up not fitting in V06 BPM.
- Suspected material stress released after reparation of one thread (welding).
- Pick-up diameter adjusted on a lathe machine.
- Assembly was possible but the pick-up leaked.
- Repolishing the sealing surface did not improve.
- 3D scan of the sealing interface reveal that sealing groove is flat but the depth is out of tolerance (tilted) ⇒ Uneven compression of the gasket

⇒ Now trying new gaskets:
- Al diamond shape more resilient
- Helicoflex with Tin coating
- Helicoflex Delta shape



Curved contact surface



Sealing and contact surfaces parallelism

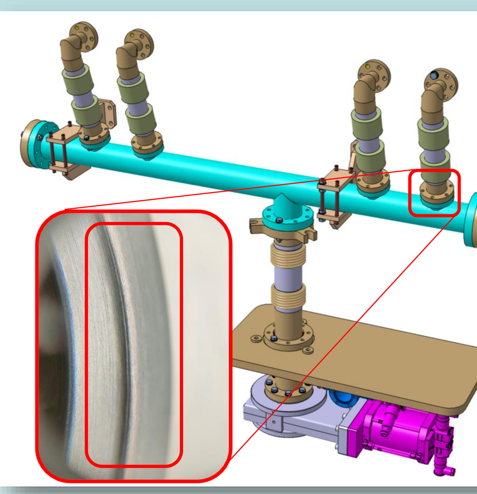
Beam Vacuum Component Leaking

- The pumping manifold connected to the SRF cavities leaked (3 out of 7 flanges).
- The CF flanges suffered during pickling and passivation treatment.
- Edge knife protection leak during process resulting in rounding edges.
- Now procuring a new manifold.
- The two beam line transitions used a double gasket configuration for beam & insulation vacuum.
- The sealing surfaces missed the last polishing to get the proper *Ra* required by Helicoflex gaskets.
- Repolishing the surface did solve one leak but fastenings are very close to the bellow. A joint wrench had to be used implying less control on the torque value.

⇒ New tooling procured to better control the torque applied.

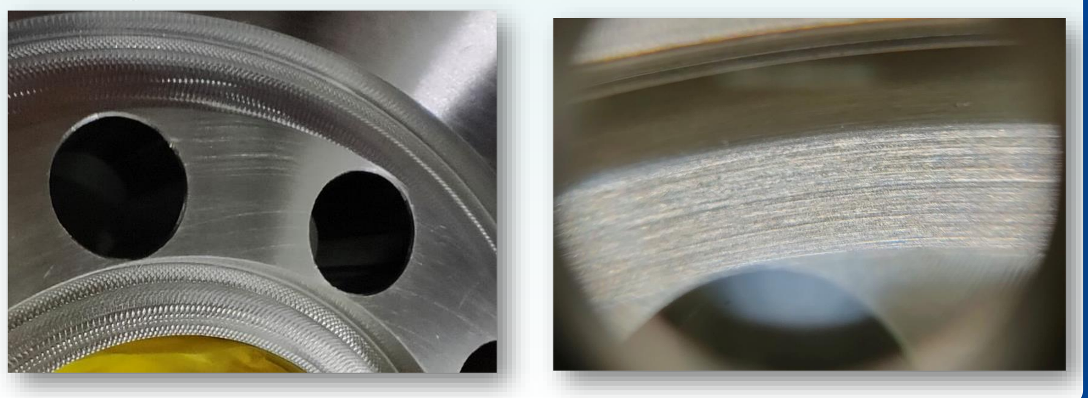
⇒ Additional gaskets with Tin plating being procured & Supplier of the gaskets involved in the analysis.

⇒ Alternative using an EPDM O-ring and Helicoflex combo being studied.



Rounded knife edge

Beam transition assemble with gate valve



Sealing surface before and after repolishing

This work was undertaken under the Broader Approach Agreement between the European Atomic Energy Community and the Government of Japan. The views and opinions expressed herein do not necessarily state or reflect those of the Parties to this Agreement.