LIPAc cryomodule assembly progress and lessons learnt

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TTC 2022 Aomori

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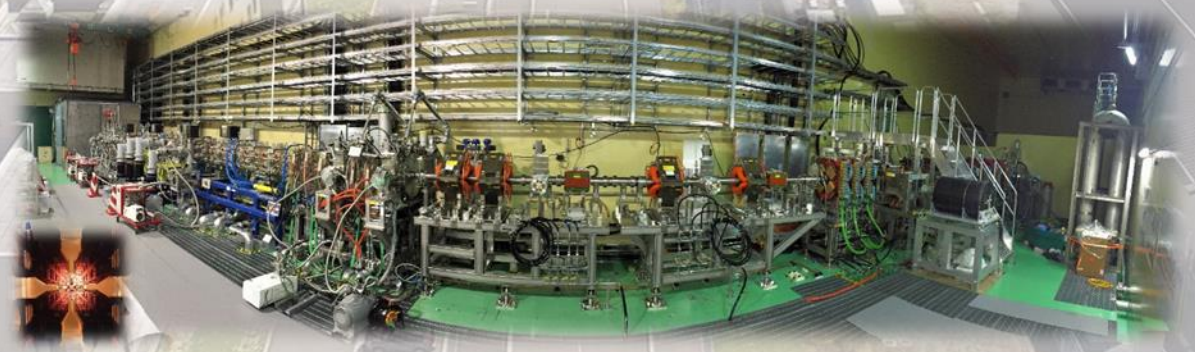
Target Facility



Accelerator Facility

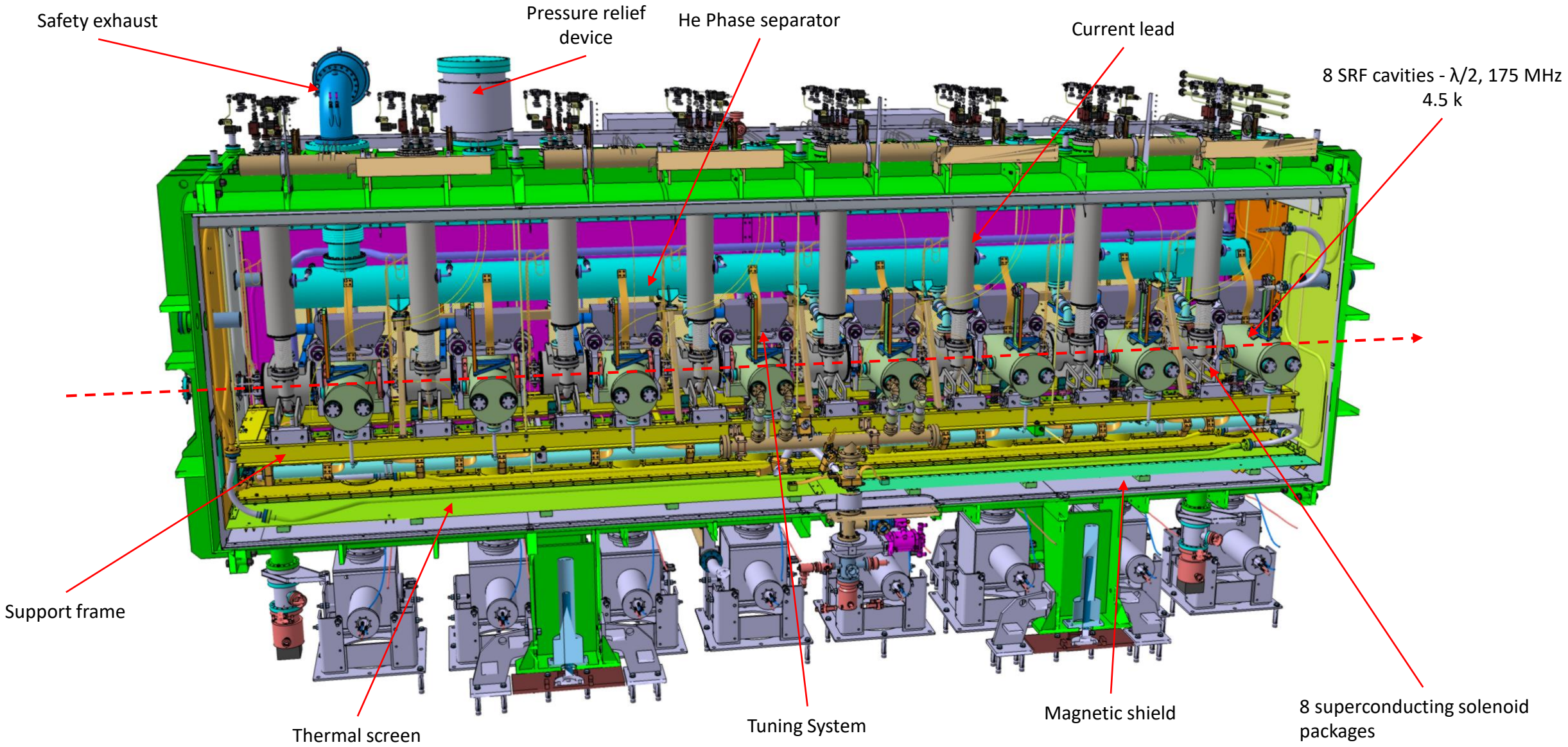
Test Facility

IFMIF/EVEDA Project

Outline

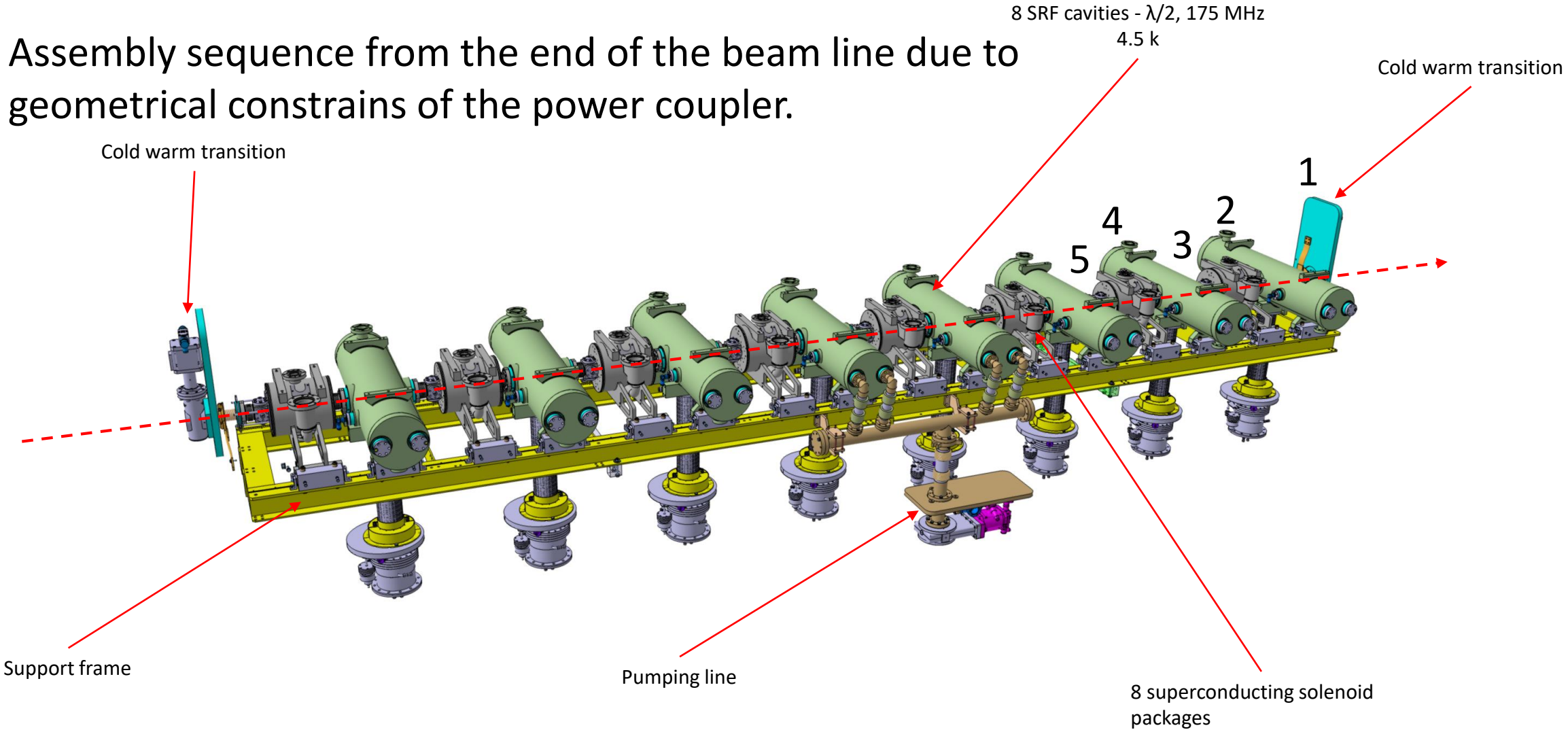
- IFMIF LIPAc cryomodule
- Assembly work on site
- Helicoflex gaskets
- Working group on the solenoids
- BPM button issue
- Last updates

IFMIF LIPAc cryomodule



IFMIF LIPAc cryomodule

Assembly sequence from the end of the beam line due to geometrical constrains of the power coupler.



Assembly is performed by RI Research Instrument Gmbh

Assembly work on site

- **In June 2022, visit of Research Instrument and F4E to Rokkasho**
  - Discussion with QST to prepare the restart of the activities (Stopped for 3.5 years)

  - Checking of the new Slow Pumping System - SPS
    - With all metal gaskets

  - The last Cavity/Coupler was suspected to have a leak
    - Permeation was suspected through O-rings of the previous SPS
    - Issue was suspected also from Aluminium gasket used for RF tests that could possibly damage Helicoflex sealing Surfaces → no damage but filing production (test done at RI)

    - Torque applied was checked
    - New leak test was done

      the last assembly was indeed leak tight

Assembly work on site

- **Trial assembly with dummy components:**
  - Necessary after a 3.5 year stop and a new team from RI
  - Assembly of a cavity with its coupler (dummy components)
  - Transfer of the assembly onto the support frame
  - Power coupler mass is asymmetrically distributed
    - Half of the fastenings required more passes to reach their final torque
- **HWR5/FPC6 assembly:**
  - First attempt was leaking
  - Aluminium filings were found on the sealing surface of the cavity from previous gasket
  - Careful cleaning of both sealing surfaces (cavity & coupler)
  - 2nd leak test looked good but helium background was too high (1.2E-9 mbar.l/s)
  - Pumping over a WE did not help, neither bake out of the pumping line
  - The calibrated leak of the Slow Pumping System was actually leaking
  - Fixed by removing it (leak detector is equipped with its own calibration leak)
  - HWR5/FPC6 assembly is leak tight (3.3E-11 mbar.l/s)

Assembly work on site

- **Following assemblies**
  - Systematic cleaning and inspection of the cavity seal groove
  - Nearly all assemblies went smoothly then
  - The two last assemblies suffered from small leaks at first attempt (~4E-10 mbar.l/s)
    - Both gaskets used at first attempt were very good
    - No filings were found when cleaning
    - Leak were solved by replacing the gasket
    - Speculated: small Al filing trapped in the interface and removed by the first Helicoflex gasket
  - Assembly of all cavities with their power coupler is now completed

Assembly done by RI


Assembly done by RI

Helicoflex gaskets

- **Consideration about Helicoflex gaskets**
  - Many people complain about Hn gaskets
  - Required the correct surface sealing preparation
  - Most of the time the torquing procedure is not correct
  - The last step is 90% of the time incorrect

It's critical to control accurately the amount of force applied on the HELICOFLEX® seal through the fasteners

5) Final pass at full torque, in a clockwise direction.
6) Repeat the step 5 until the tightening is uniform, with each bolt pulling the same load.

  - This last step can take up to 10 iterations if the load is asymmetric on the assembly
  - Re-torque after 12-24 hours at room temperature

  - Use of other gasket type (diamond shape..) is possible but may produce fillings. (observed during a test done on a dummy interface)

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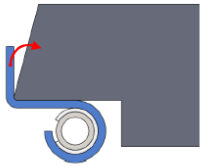
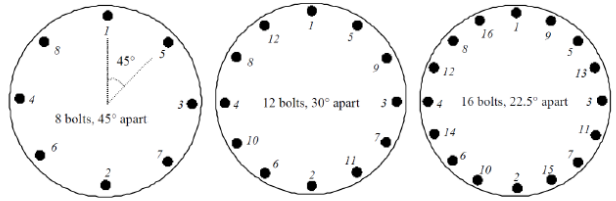
Folding tab



1) Put seal in place
2) Fold tab at 3 locations minimum (120° apart), while maintaining the seal against the flange.

f. Tightening

It's critical to control accurately the amount of force applied on the HELICOFLEX® seal through the fasteners, hence:
- Always use a torque wrench or other controlled-tensioning device (recently calibrated)
- Always torque nuts in a star pattern (see pictures below)
- Number the bolts with an indelible marker to make the process easier.



The following sequence must be done during the seal seating condition at room temperature and without pressure.
1) Tighten nuts by hand
2) Using a torque wrench, torque to 20-25% of the full torque according to the star pattern *
3) Torque to 50-60% of the full torque according to the star pattern
4) Torque to the full torque according to the star pattern
5) Final pass at full torque, in a clockwise direction.
6) Repeat the step 5 until the tightening is uniform, with each bolt pulling the same load.

* When the minimum load to apply on the seal (Fb) is greater than the seating load of the seal (Fj), the torque value allowing the metal-to-metal touch must be applied. Hence, the compression of the seal is smooth and the seal is protected. This torque value can be calculated using the formula:

$$\text{Torque} = \frac{\text{Fj} \times \text{min. torque value}^{2}}{\text{Fb}}$$

It is recommended to re-torque 12-24 hours after initial installation. The re-torque must be done at room temperature.

[2] For the chosen friction coefficient.

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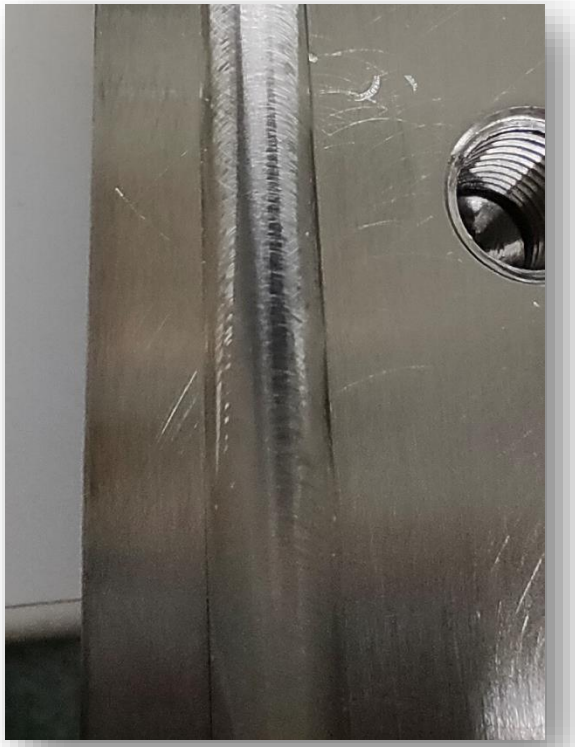
EnPro Industries companies

Helicoflex gaskets

- **Non conformity on HN and EPDM sealing surfaces**
  - The first cold warm assembly was leaking at inspection
  - The two cold warm transitions had no rework of their sealing surfaces after machining



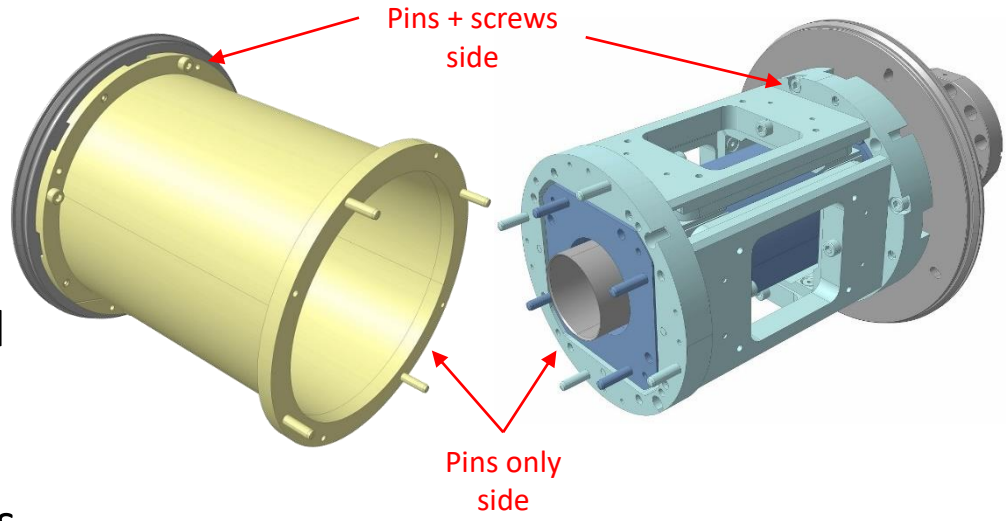
Incorrect sealing surfaces with machining traces

Hn gasket surface used on good surface preparation

Hn gasket surface used on bad surface preparation

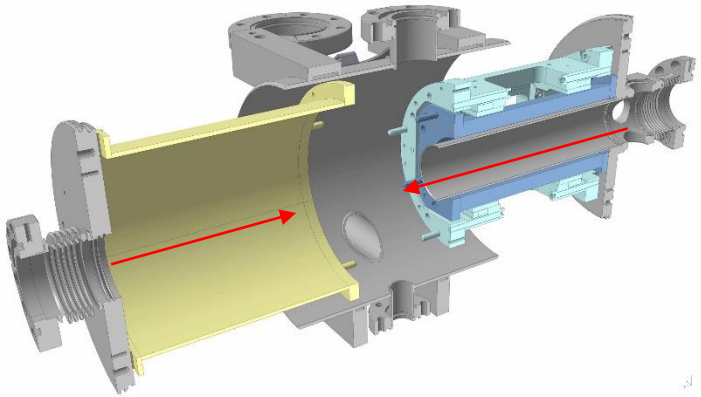
Working group on the solenoids

- **A rattling noise was detected during the HPR process of the solenoids → a screw was found in the Helium tank**
  (see *Troubleshooting during high pressure rinsing of superconducting solenoid packages for LIPAc, T. Ebisawa, TTC 2022)*



- During the assembly each coil was centred with 4 pins and locked with 4 screws to one of the helium vessel flange.
  - The coils are covered by Epoxy (risk of damage is low)
  - The current is ramped, limiting the movement of the screws if any (due to magnetisation)

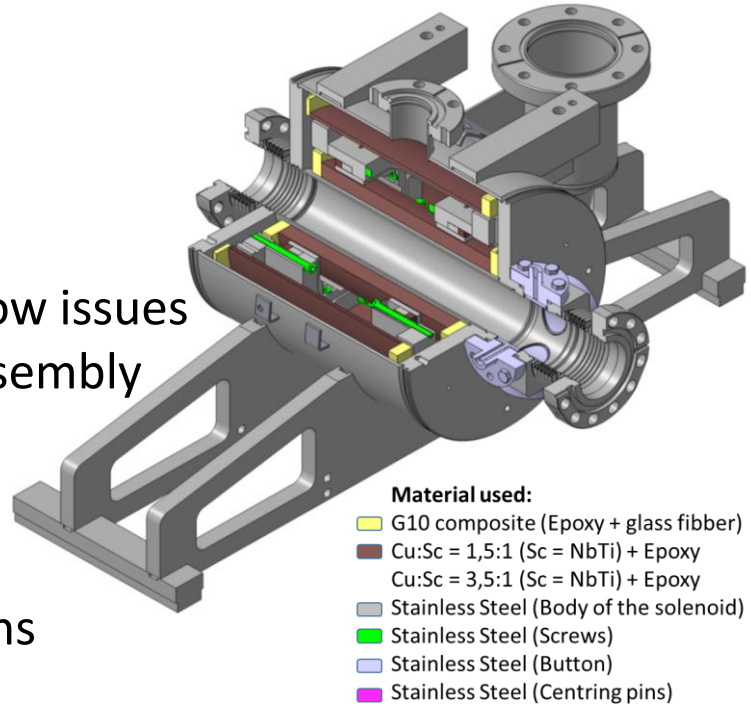
- It was decided to make a CT scan of all solenoids to inspect all screws and pins status
  - Fast technique
  - Can be done with the solenoids in double bags

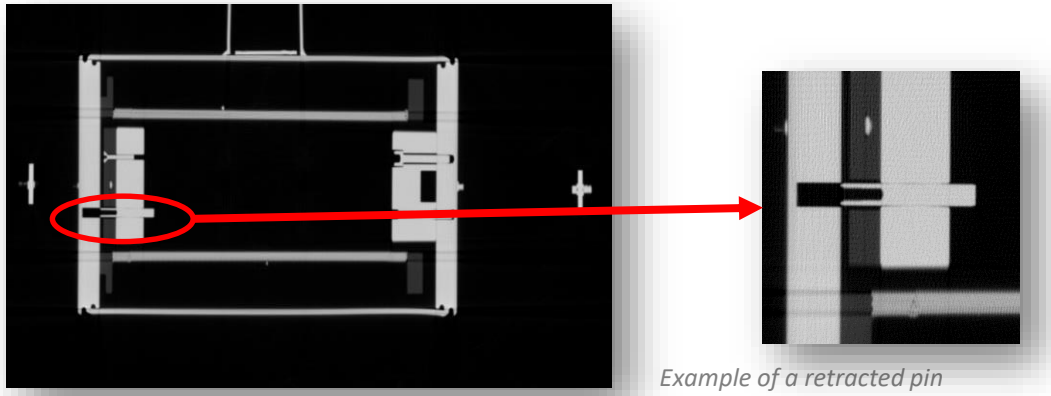


Working group on the solenoids

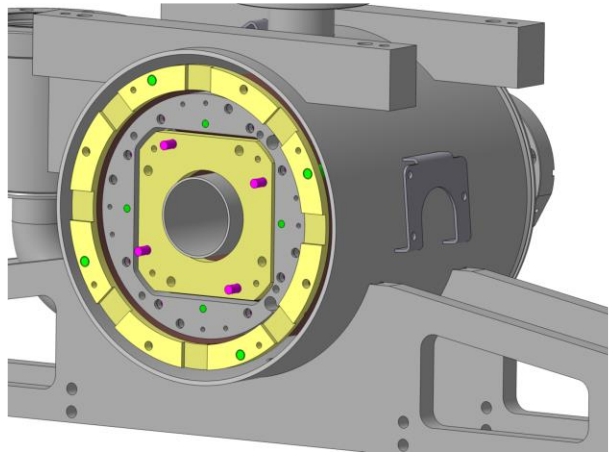
- In July all solenoids were send to Hitachi for the CT scan
- Many solenoids have retracted pins (partially and fully)
- Two Solenoids could possibly have some strong issues, a third one possibly low issues
  - 1 - Retracted/missing pins + 1 cable strand possibly damaged at the assembly
  - 2 - Retracted/missing pins
  - 3 - 2 missing pins for the inner solenoid

  - Only the sides without screws are affected by the retracted/missing pins
  - This should limit the impact on the alignment of the coils
  - Any move of the coils will quench the magnet when ramping the current





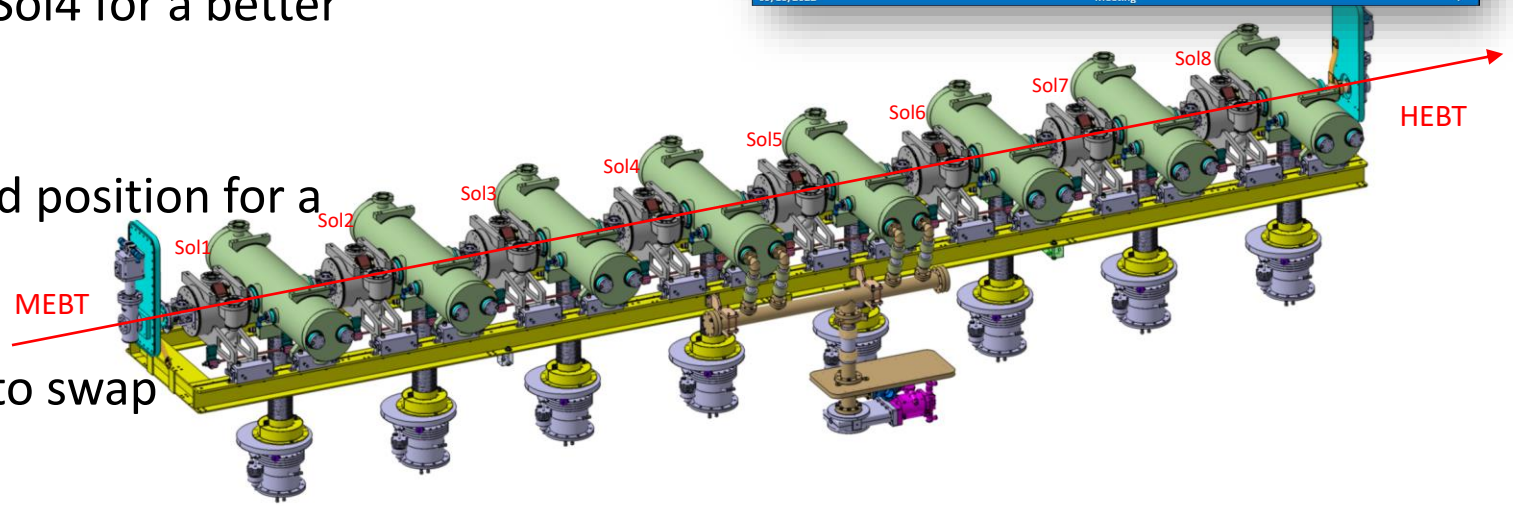
Example of a retracted pin



Working group on the solenoids

- **Special Beam Physics Group (BPG) meetings were dedicated to analyse the consequences of one or more missing solenoid on the beam line**
  Is degraded mode of the LINAC possible?

  - Different simulations done (QST and CEA)
  - First and last solenoid are critical for the operation of the LINAC
  - Solenoid 4 and 7 can be turned off (Sol4 for a better beam physics)
  - Solenoid 2 will be the third dedicated position for a degraded mode
  - Disassembly scenario was assessed to swap with new solenoids

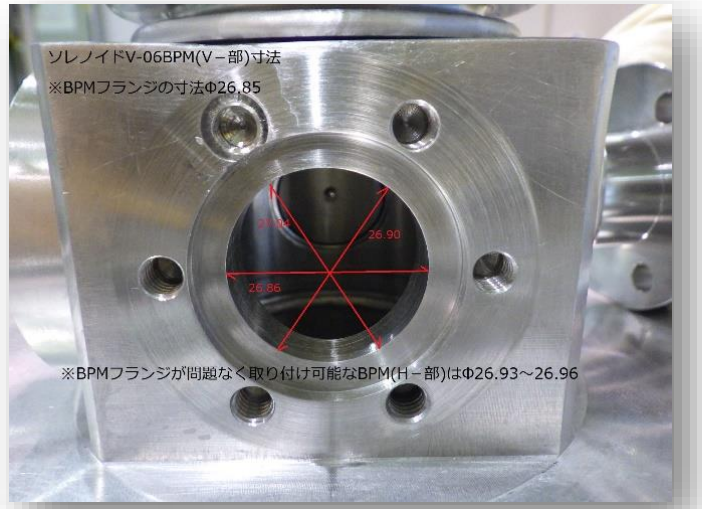


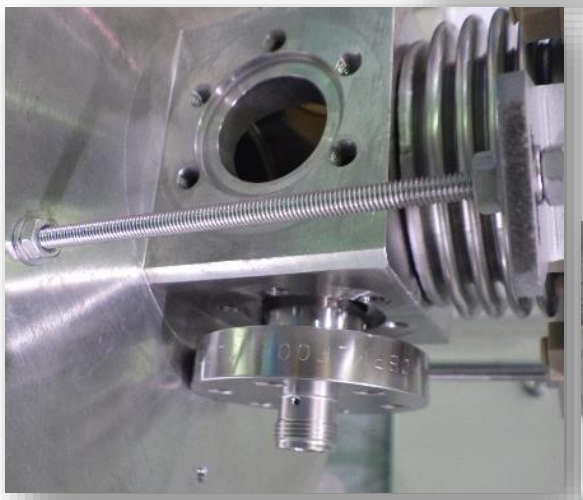
BPM button issue

- **BPM buttons were assembled in cleanroom after HPR by MHI**

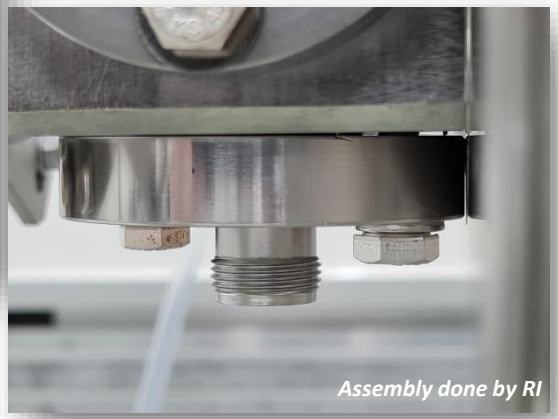
- **On one solenoid, assembly of one button was impossible**
  - This solenoid was previously repaired due to a thread leaking in beam line
  - Thread was recharged by welding prior to a new tapping
  - Possibly, heat may have deformed the BPM cavity (tolerances are very thin)

  - Button was polished by 0.05 mm and assembled but a small gap remains. New polishing on going





Before polishing



After polishing

Last updates

- Seven solenoids have been leak tested prior to assembly.
- One solenoid is waiting for its last BPM button.
- Rework of the CWT sealing surfaces still on going.

Assembly done by RI

Thanks to my colleagues involved:

T. Ebisawa, K. Kumagai, T. Yanagimachi

D. Trompetter, A. Gottschling, S. Bauer and Thomas, Michael, Kevin, Tom from RI

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And many more