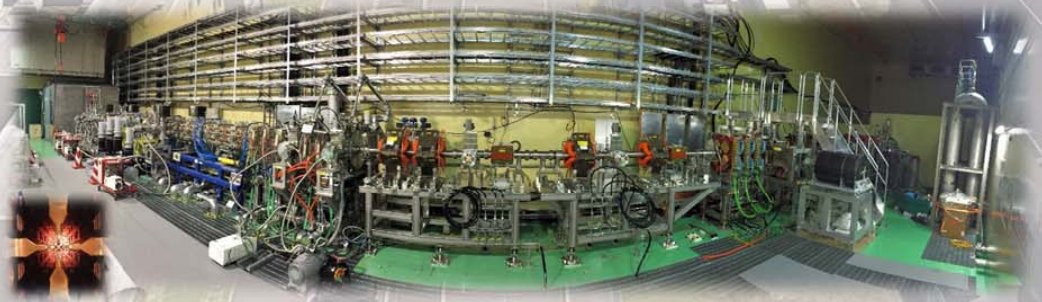
Engineering and Assembly of the IFMIF / EVEDA SRF Linac

G. Phillips (Fusion for Energy)

TTC 2022

Aomori by VC, 26-Jan-2022

Target Facility



Accelerator Facility

Test Facility

IFMIF/EVEDA Project

Introduction

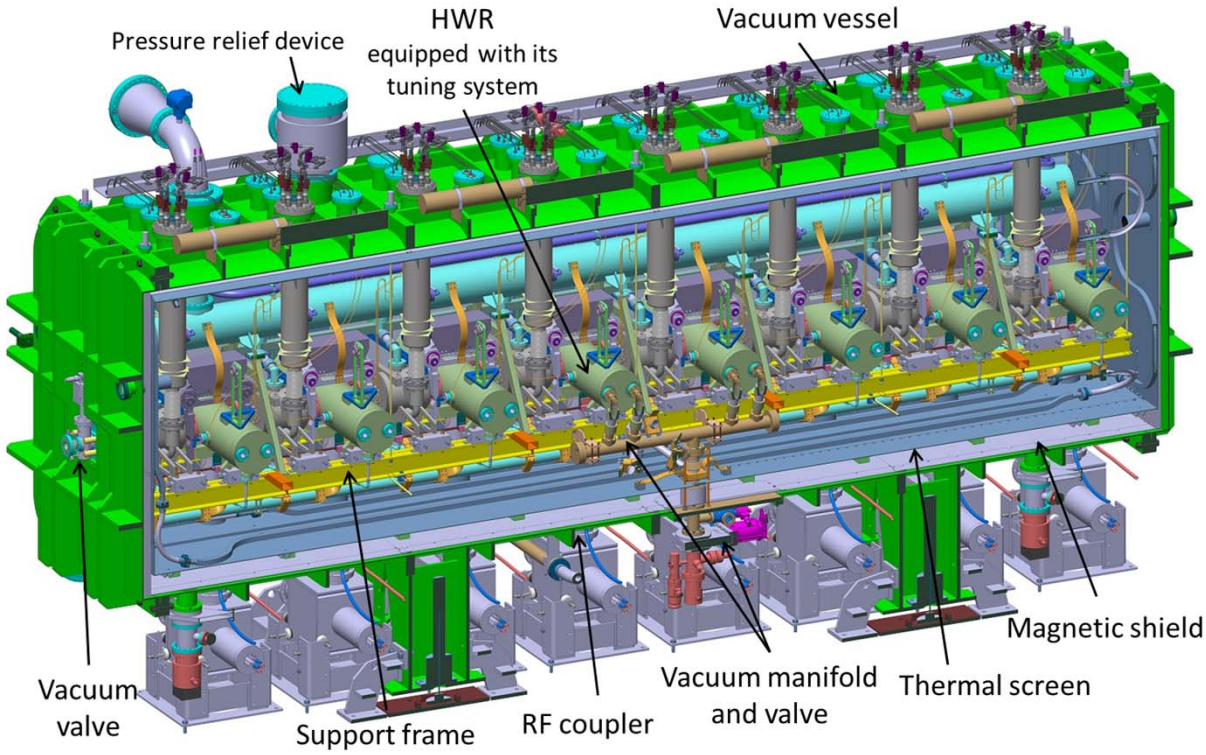
- Contributors and Responsibilities
- Engineering
- Assembly

Contributors and Responsibilities

- CEA (France):
  - Design, manufacture and testing of the superconducting cavities and the power couplers
  - Design and manufacture of the cryostat and all helium circuitry for the complete cryomodule
- Ciemat (Spain):
  - Design, manufacture and testing of the superconducting solenoids and current leads
- Fusion for Energy (Europe):
  - Assembly of the cryomodule at Rokkasho, Japan
  - Interface between EU and Japanese collaborators (QST)
- QST (Japan):
  - Provision of the worksite for the assembly work
  - Installation in the beam line

Engineering for the SRF Linac

- Ciemat (Spain):
  - Superconducting solenoids and current leads
- CEA (France):
  - Everything else



Engineering summary can be found in the proceedings of IPAC 2015:
https://accelconf.web.cern.ch/IPAC2015/papers/thpf006.pdf

All Subcomponents in Japan

There have been delays, but all of the hardware has now been delivered to Japan (final solenoid delivered in December 2021)

Phase separator + magnetic shield

Vacuum Vessel

Assembly Responsibilities

- QST (Japan): responsible for providing the working areas, including cleanroom for the assembly
- CEA: assembly guidelines
- F4E (EU): contracted RI (Germany) to complete the assembly

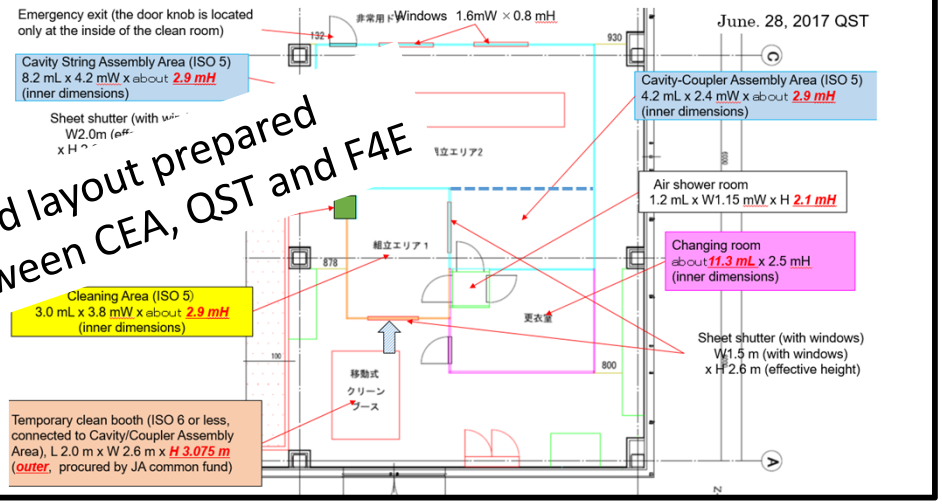
Cleanroom Preparation

- ISO 5 Cleanroom (QST)
- Contract placed in 2017
- Installation complete in 2018

Specifications (for "call for tender") of the clean room installed at the DEMO Joint Research Building in the IFERC site (Final)

#	Item	Specification	Note
1	Cavity String Assembly Area	Inner dimensions (min.): 8.2 mL x 4.2 mW x about 2.9 mH (under the light housing) Air flow: laminar flow (down to 100 c m above the floor at least) Cleanness: ISO class 5 (0.3 µm particles, at the initial condition) Fun Filter Units : Type MAC-IIA-151DCCON (or equivalent) Filter efficiency: >99.99% (@particles larger than 0.3 µm) Lighting system: LED panels, LED emergency lights (2 units) Panels for wall, ceiling: colored steel non-combustible panel with insulation (thickness: 42 mm, louver structures at the bottom for outlet air flow) Windows (quantity: 2): Size: 1,600 mmW x 800 mmH Emergency door (quantity:1): 800 mmW x 2,000 mmH (inner dimensions ,with window) Floor: PVC sheet (2.0 mm², antistatic) Sheet shutter entrance (with window): Effective size 2 mW x 2.6 mH	Compliant with ISO14644-1 See the attached figure of the arrangement of the Clean Room. Cavity String Assembly Area and Cavity/Coupler Assembly Area are connected to each other without any partition. Illuminance: 1,000 Lx @1000 mm above the floor Arrangements of FFUs (total quantity: 42)/LED panels (total 24 panels) and Gap size betw FFUs are beino
2	Cavity/Coupler Assembly Area	Inner dimensions (min.): 4.2 mL x 2.4 mW x about 2.9 mH (under the light housing) Air flow: laminar flow (down to 100 c m above the floor at least) Cleanness: ISO class 5 (0.3 µm particles, at the initial condition) Fun Filter Units: Type MAC-IIA-151DCCON (or equivalent) Filter efficiency: >99.99% @particles larger than 0.3 µm) Lighting system: LED panels , LED emergency lights (1 unit) Panels for wall, ceiling: colored steel non-combustible panel with insulation (t mm, louver structures at the bottom for outlet air flow) Floor: PVC sheet (2.0 mm², antistatic)	
3	Cleaning Area	Inner dimensions: 3.0 mL x 3.8 mW x about 2.9 mH (under the light housing) Air flow: laminar flow (up to about several tens cm above the floor, to be confirmed). Cleanness: ISO class 5 (0.3 µm particles, at the initial condition) Fun Filter Units: Type MAC-IIA-151DCCON (or equivalent, quantity: 10)	Compliant with ISO14644-1 See the attached figure of the arrangement of the Clean Room. Illuminance: 1,000 Lx @1000 mm

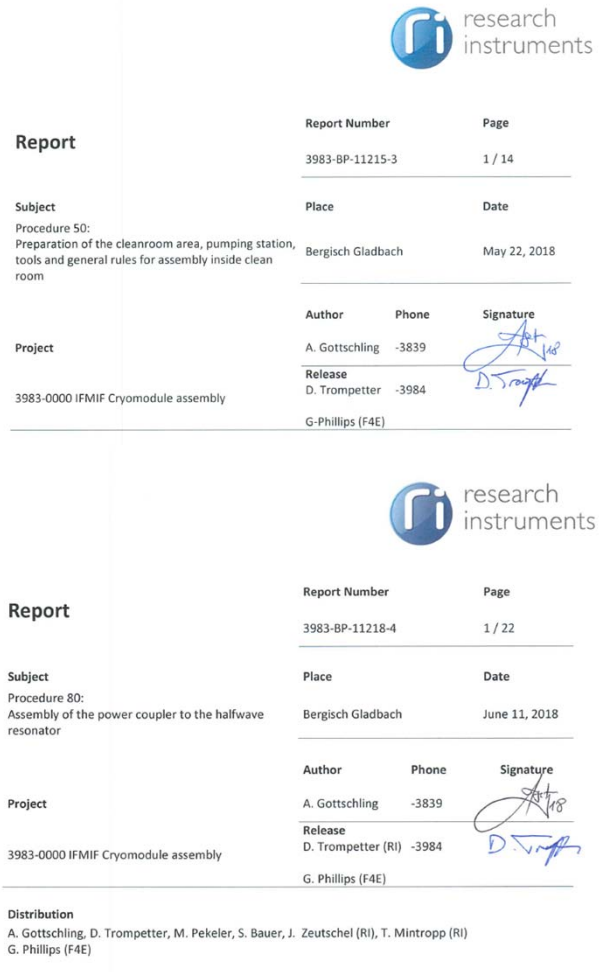
Specification and layout prepared collaboratively between CEA, QST and F4E



Preparation for the Assembly

- Detailed procedures – RI
- Reviewed with CEA, F4E, QST and RI

010_3983-BP-11211-worksite-prep-and-clean-up
030_3983-BP-11213-HP-DR-of-spec-purp-tooling
040_3983-BP-11214-leak-pres-test-procedures
050_3983-BP-11215-handling-inside-cleanroom
060_3983-BP-11216-incoming-inspection
070_3983-BP-11217-installation-of-the-auxiliary-guides
080_3983-BP-11218-cavity-coupler-assembly
090_3983-BP-11219-assembly-of-the-beam-line-components
100_3983-BP-11220-0-Inv-rod-inst-Align-stg-I-III-cav-string
110_3983-BP-11221-0-Cold-mass-preparation
120-3983-BP-11222-0-Installation-magnetic-and thermal-shield
130-3983-BP-11223-0-Cold-mass-ins-Tighten-int-flgs
140-3983-BP-11224-0-Preparation-of-the-cryo-transp
150-3983-BP-11225-0-Assembly-vault
160-3986-BP-11226-0-Leak-test-at-room-temperature-REPORT
220_3983-BP-11232-list-of-detailed-procedures
Control-Plans



research instruments

Report

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3983-BP-11215-3	1 / 14

Subject
Procedure 50:
Preparation of the cleanroom area, pumping station, tools and general rules for assembly inside clean room

Place	Date
Bergisch Gladbach	May 22, 2018

Project
3983-0000 IFMIF Cryomodule assembly

Author	Phone	Signature
A. Gottschling	-3839	
Release		
D. Trompetter	-3984	
G-Phillips (F4E)		

research instruments

Report

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3983-BP-11218-4	1 / 22

Subject
Procedure 80:
Assembly of the power coupler to the halfwave resonator

Place	Date
Bergisch Gladbach	June 11, 2018

Project
3983-0000 IFMIF Cryomodule assembly

Author	Phone	Signature
A. Gottschling	-3839	
Release		
D. Trompetter (RI)	-3984	
G. Phillips (F4E)		

Distribution
A. Gottschling, D. Trompetter, M. Pekeler, S. Bauer, J. Zeutschel (RI), T. Mintropp (RI)
G. Phillips (F4E)

Preparation for the Assembly

- Trial cavity-coupler assembly – completed at RI with the cleanroom operators allocated to the job (note they are no longer available)

Cavity lowered on cavity-coupler assembly frame

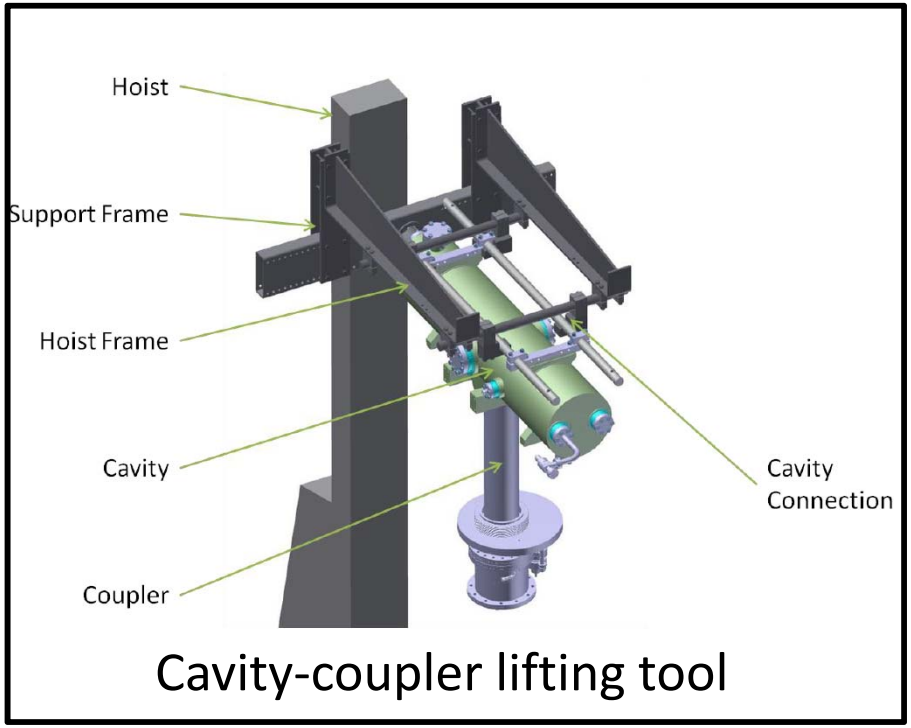
Cavity-coupler alignment and assembly

Transfer of cavity-coupler to cold mass support frame

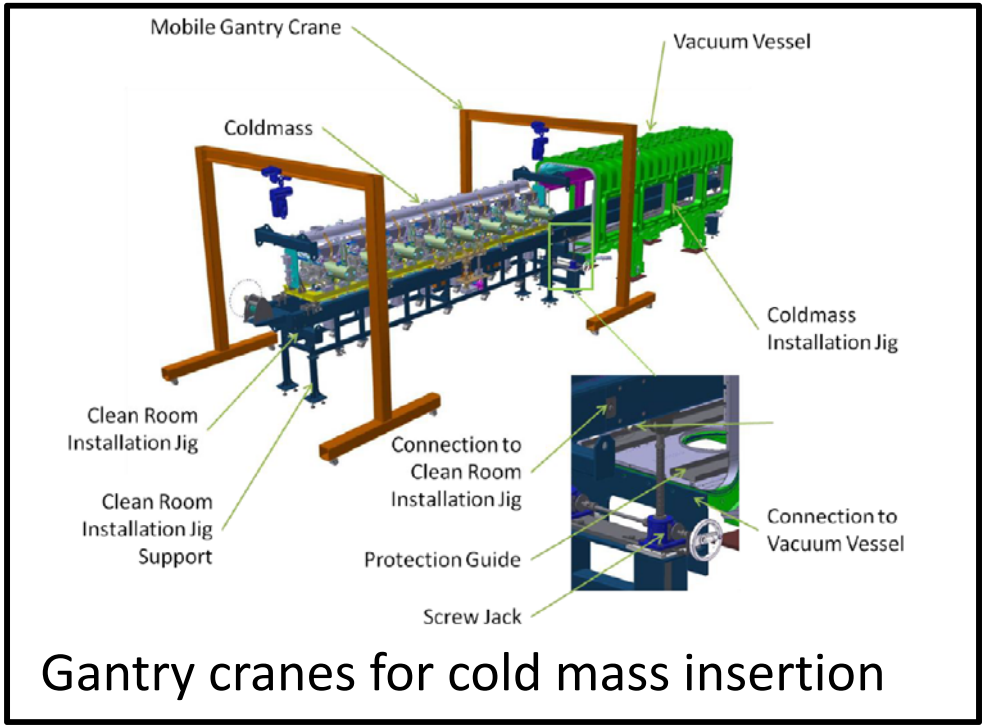
Cavity lowered onto support frame and aligned with solenoid

Preparation for the Assembly

- Preparation of the tooling – RI
- All tooling now in Rokkasho



Cavity-coupler lifting tool

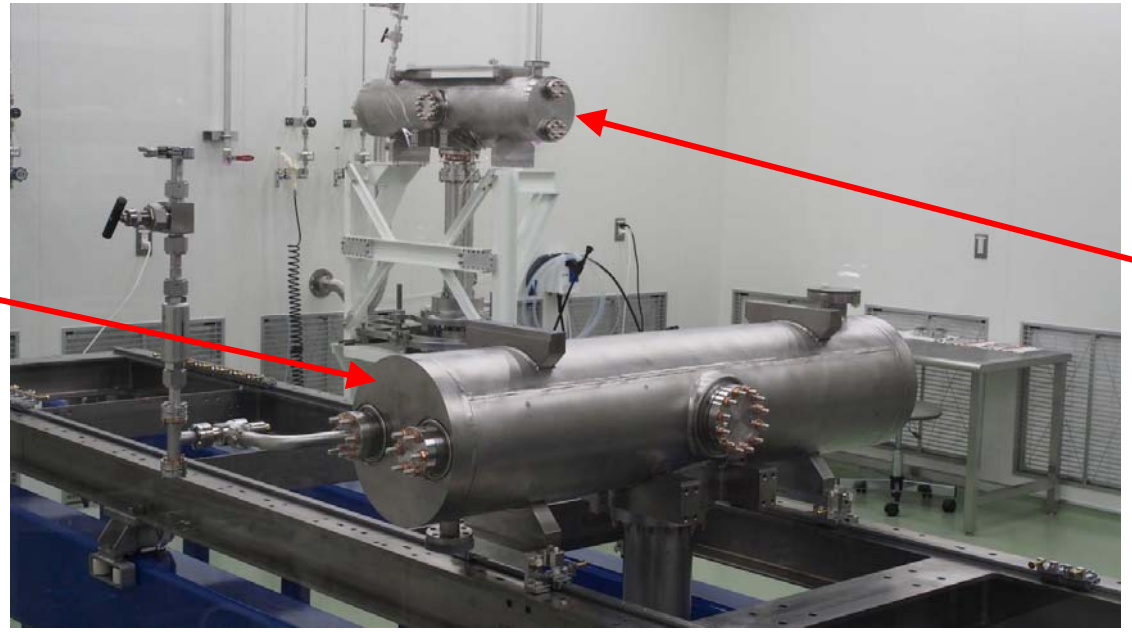


Gantry cranes for cold mass insertion

Start of Assembly (2019)

- Cleanroom work:
  - Cavity-coupler assembly
  - 3 attempted, 1 success, 2 undecided (leak test inconclusive)

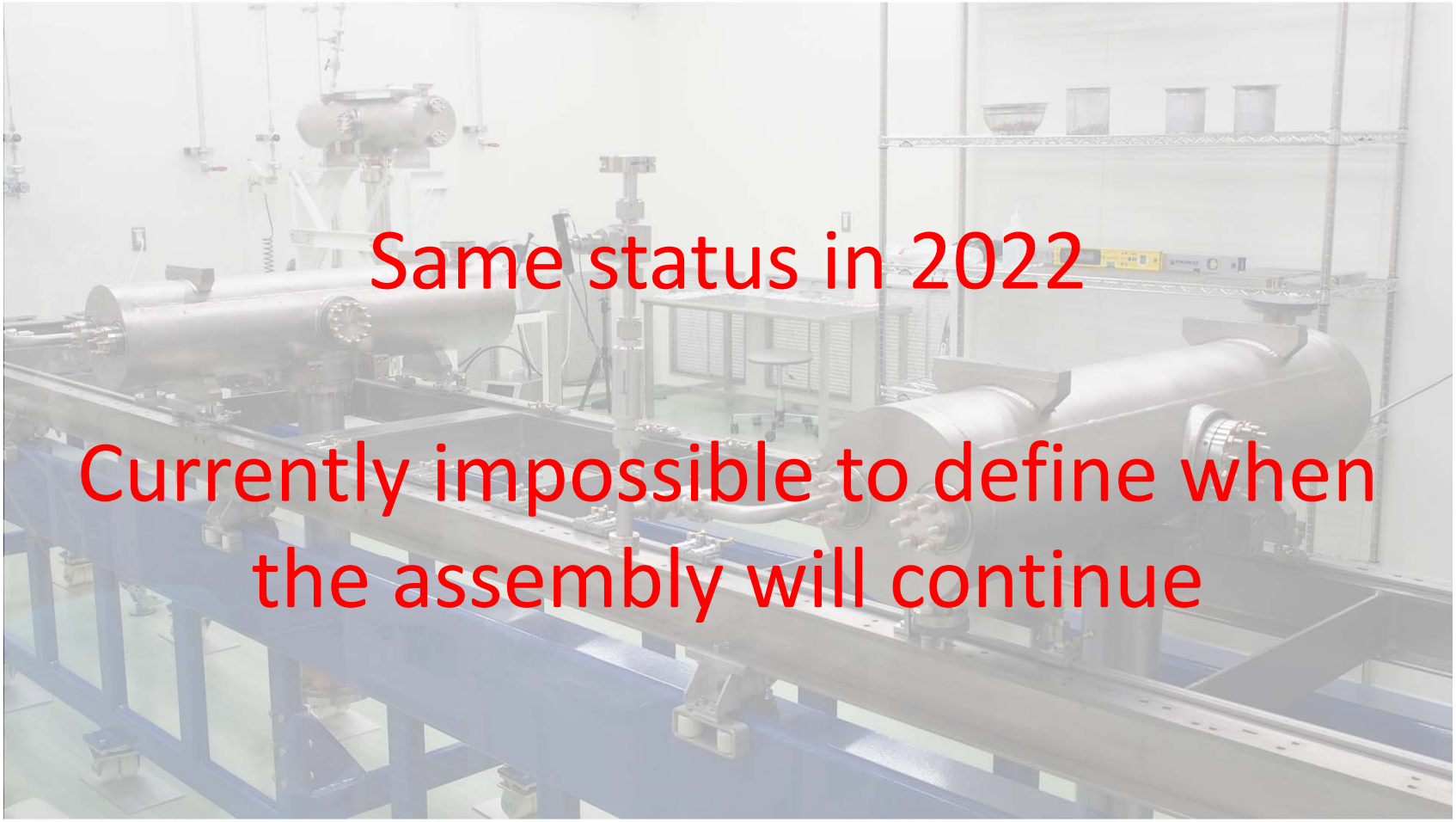
First cavity-coupler assembly mounted on support frame



Second cavity-coupler assembly in preparation on cavity-coupler assembly frame

Start of Assembly

Assembly now on hold



Remaining Assembly Work

- Cleanroom work:
  - Checks of the existing cavity coupler assemblies
  - Remaining cavity-coupler assemblies
  - Cavity-coupler + solenoid assembly and mounting on the support frame
- Outside cleanroom work:
  - Cold mass preparation:
    - Assembly of the helium piping
    - Assembly of the phase separator
    - Installation of MLI
  - Preparation of the vacuum vessel with magnetic and thermal shields
  - Insertion of cold mass into vacuum vessel
  - Transfer from assembly area to accelerator vault
  - Installation of current leads
  - Final assembly testing

New Challenges

- The main challenges arise from the long delay between the preparation work and the continuation of the assembly
  - Assembly team will be different
  - Re-training will be required for the new technicians
  - Additional time will be required for the assembly activities
- Additionally, access to Japan is now restricted due to COVID, so it is impossible to propose a start date
- Hardware delivered to Japan is not in ideal storage conditions
  - Some of the tooling has been stored outside, so may require rework
  - Additional checks may be required when preparing the assembly

Summary

- Assembly preparations were effectively completed in a collaborative manner between all stakeholders

- First main difficulty was delayed hardware delivery
- Second main difficulty is related to COVID travel restrictions

- We do not know when assembly work will re-start