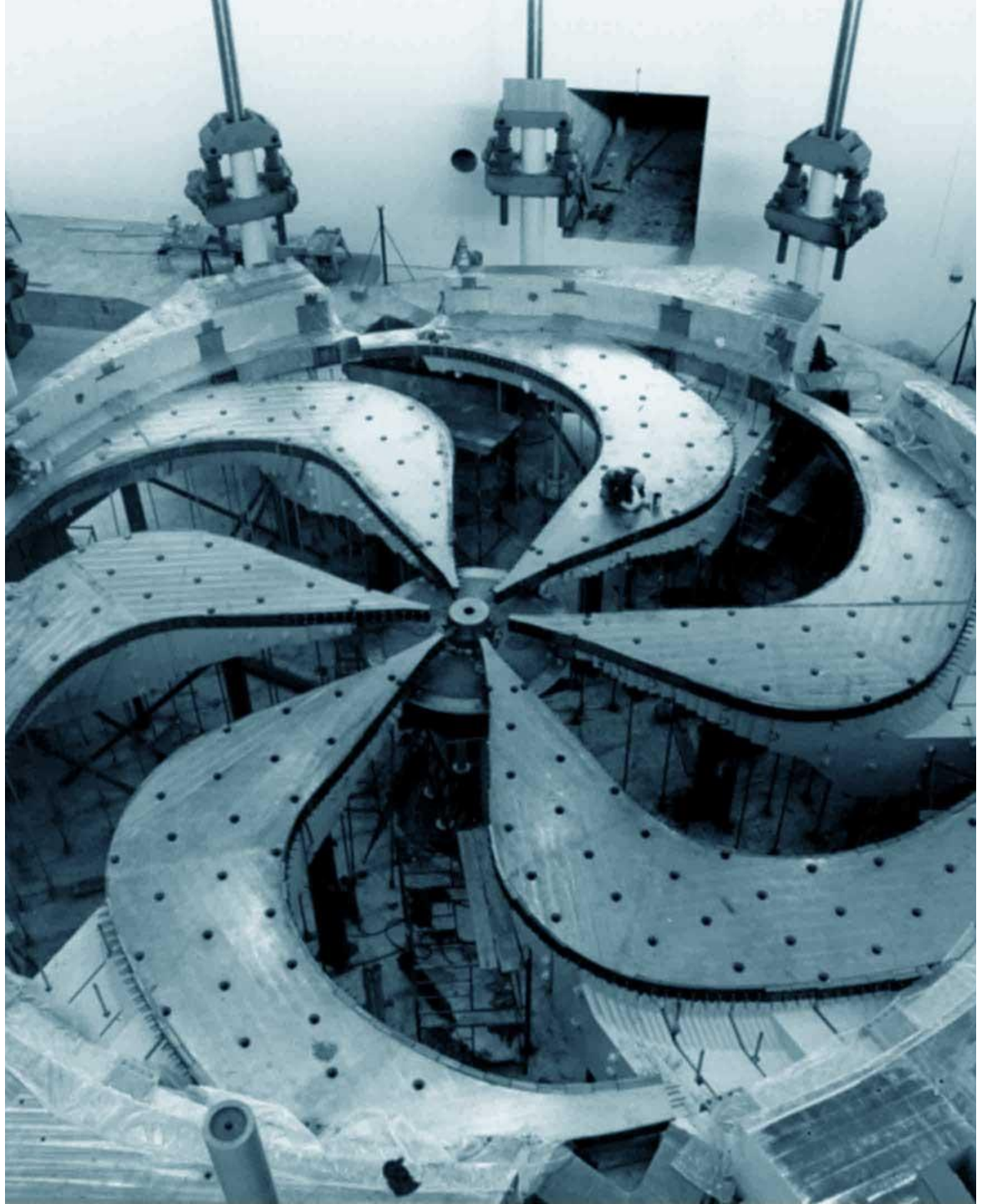
Preparations for Hi-Lumi RFD CM Assembly at TRIUMF

Zhongyuan Yao

WG4: Special Cryomodules and Advanced Auxiliary Systems

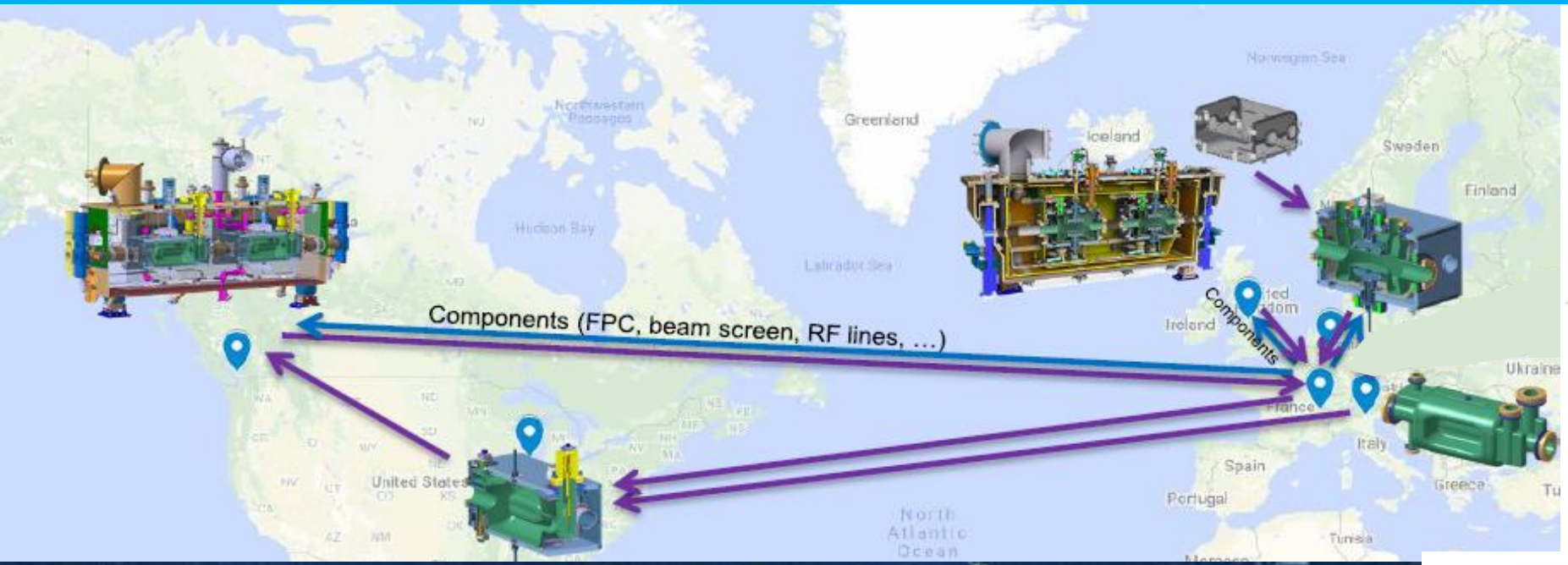
Apr. 10, 2025

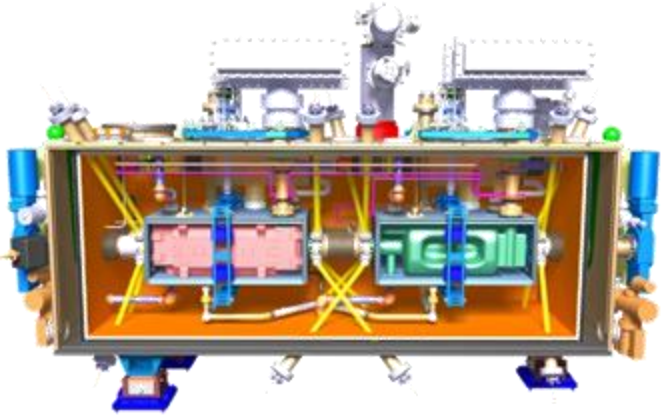


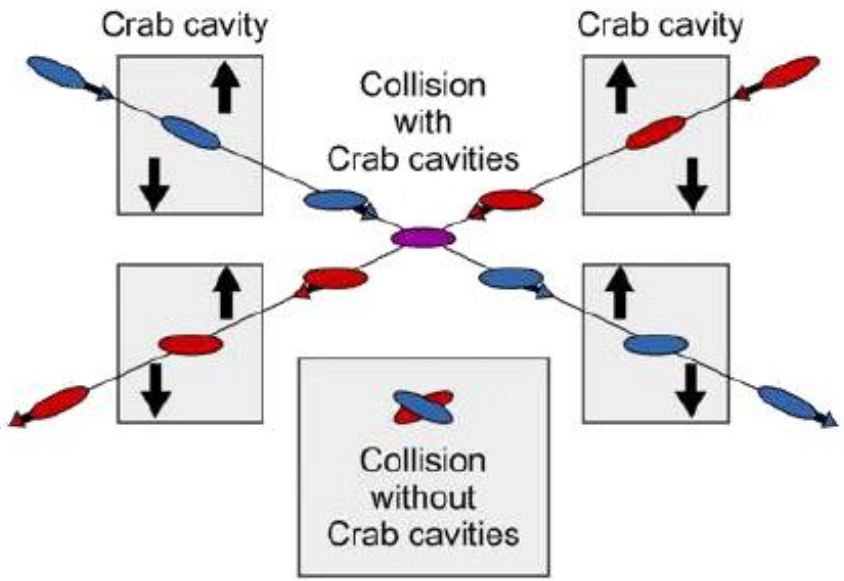
TTC, Daejeon, Apr. 8-11, 2025

Discovery, accelerated

TRIUMF is part of global collaboration (CERN, USA, UK) that will deliver RFD Crab Cavity modules as a Canadian contribution to Hi-Lumi

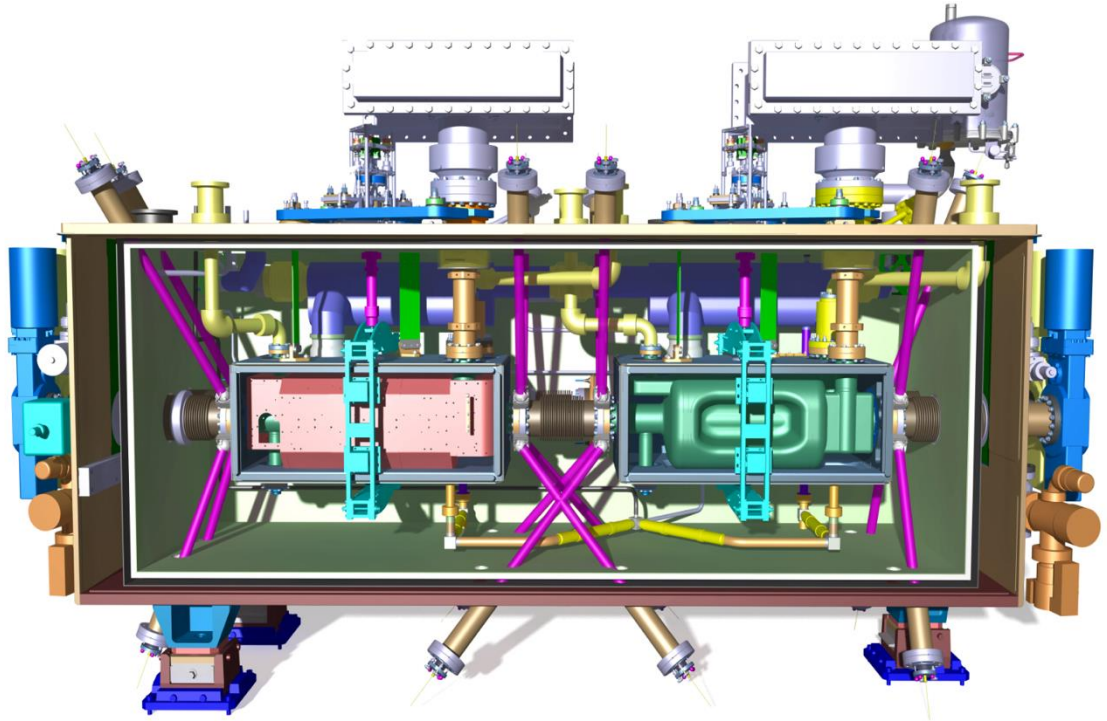






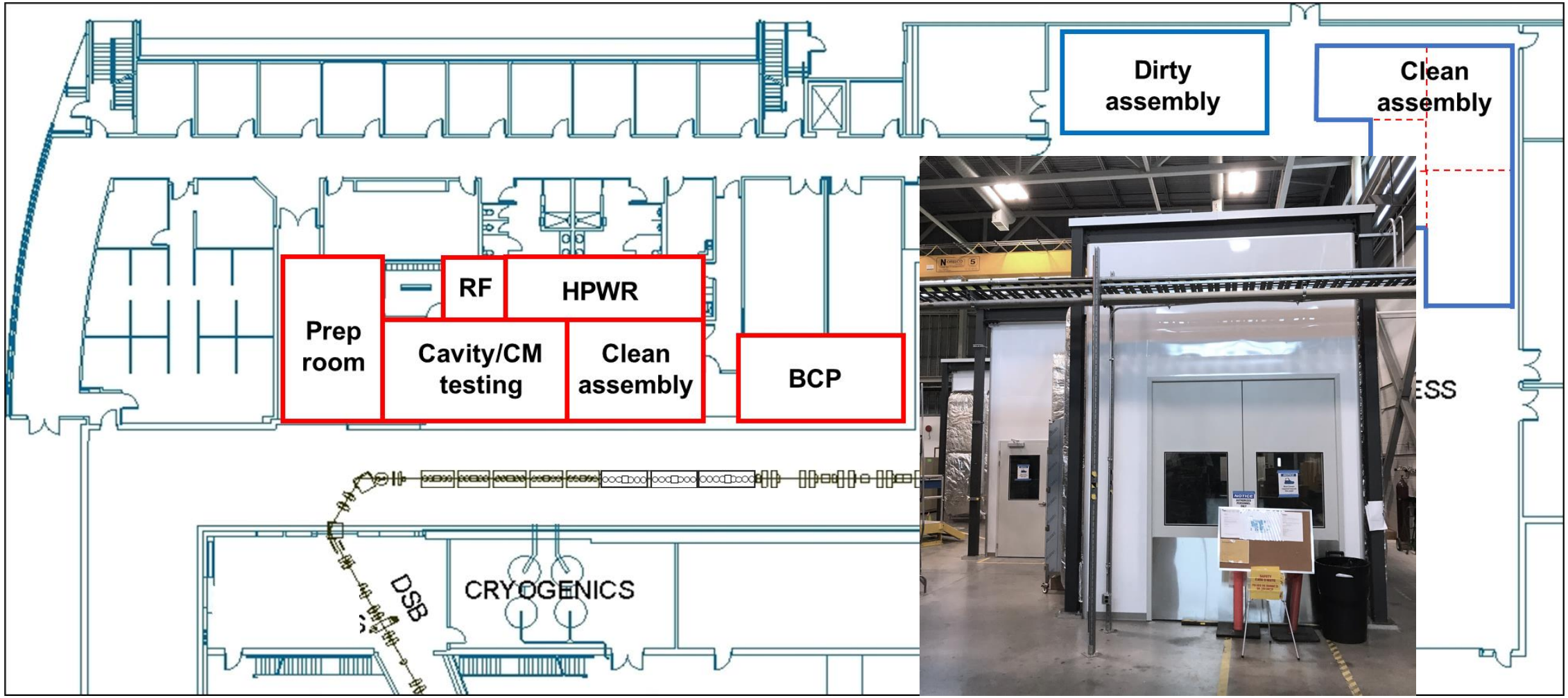
Scope of Canadian Contribution

- TRIUMF to work with CERN and UK colleagues to develop RFD cryomodule design and tooling
- TRIUMF to receive and re-qualify 10 dressed RFD resonators (US-AUP scope)
- TRIUMF to install the fundamental power coupler (CERN scope) and to assemble each pair of RFDs into five hermetic strings
- TRIUMF to assemble hermetic strings into five crymodules and qualify performance
- TRIUMF to package and ship cryomodules to CERN



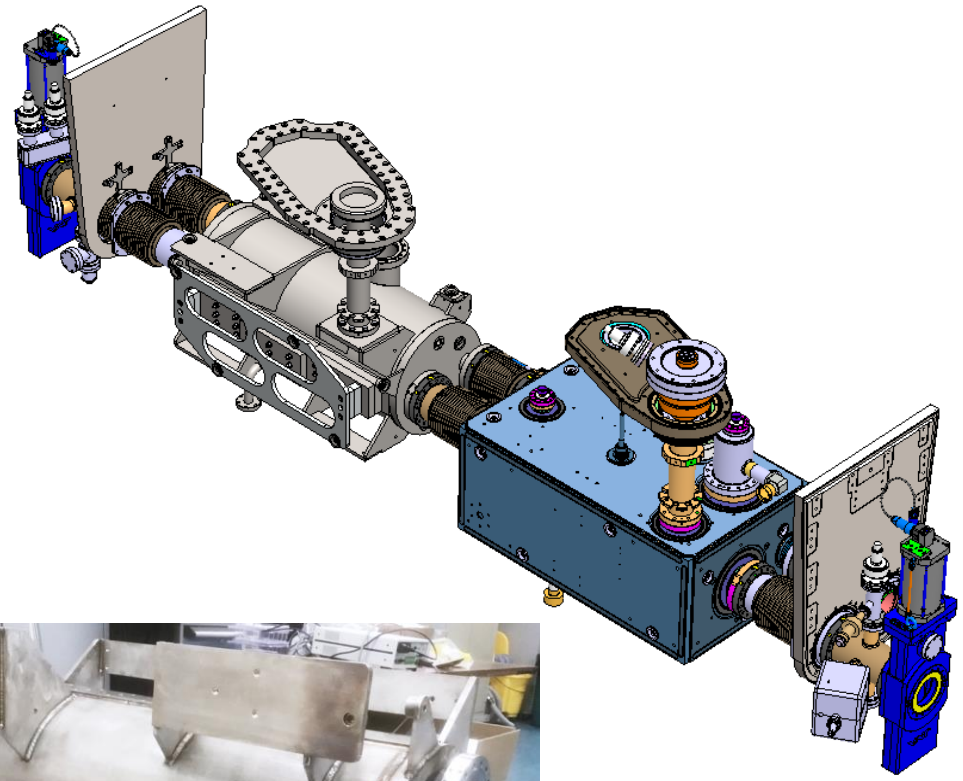
SRF Facilities – Hi-Lumi Upgrade

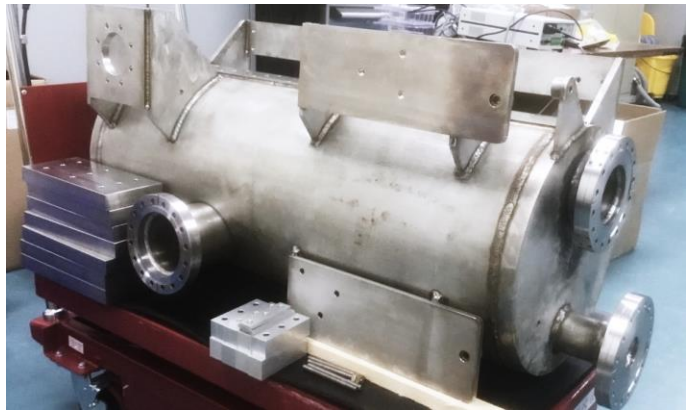
- To improve the throughput of Hi-Lumi CMs we installed a second clean-room in the ISAC-II experimental hall
- The clean room will allow dedicated string assembly over the life of the project



Dummy Cavity for TCM0 String

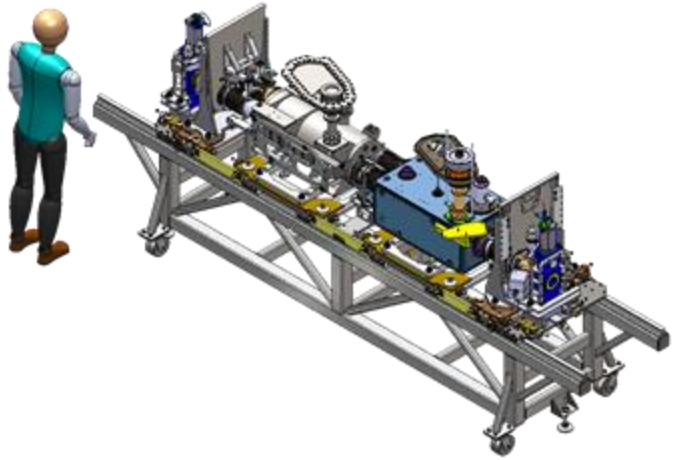
- AUP delivered one cavity (TC0) for TCM0
- TRIUMF has designed and fabricated a dummy cavity to replicate the RFD cavity
  - Identical LHe volume and mass as the actual cavity
  - Identical beam and helium interfaces as the RFD cavity
  - Identical support interfaces
- Have been cryogenically tested
- Will be used for TCM0 string assembly

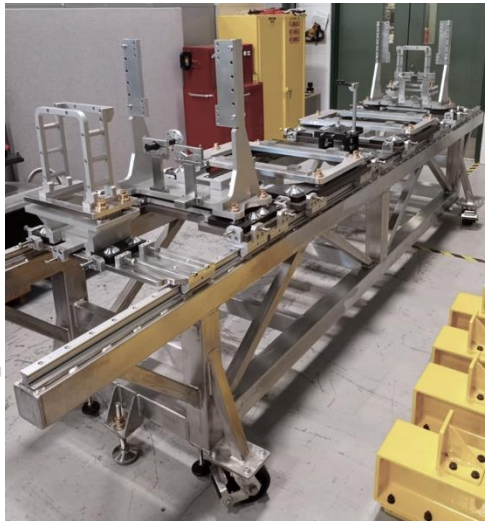


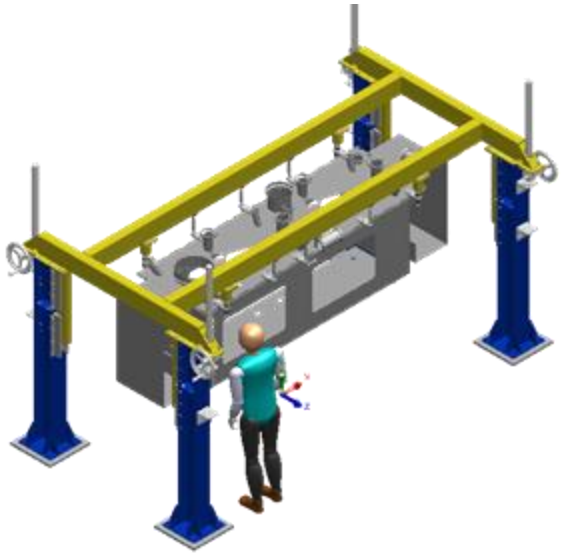


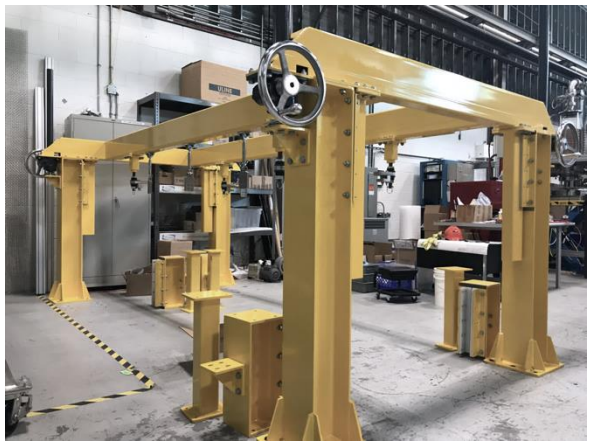
Other Infrastructure

- String assembly cart – Assembled
- Top assembly stand – Assembled
- Cavity manipulator – Commissioned
- 4K/2K cryo-insert – Commissioned
- Pumping/Venting – Commissioned



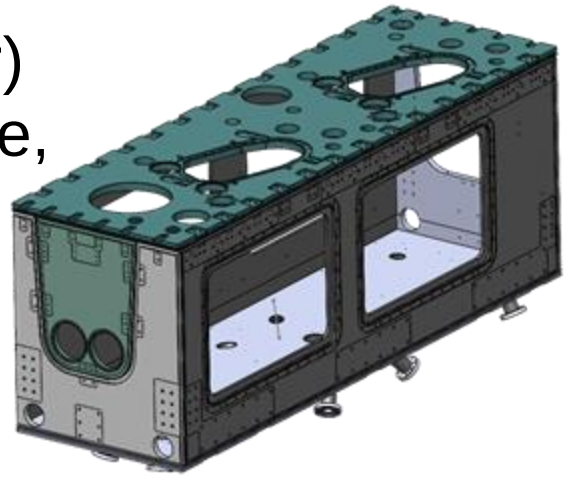


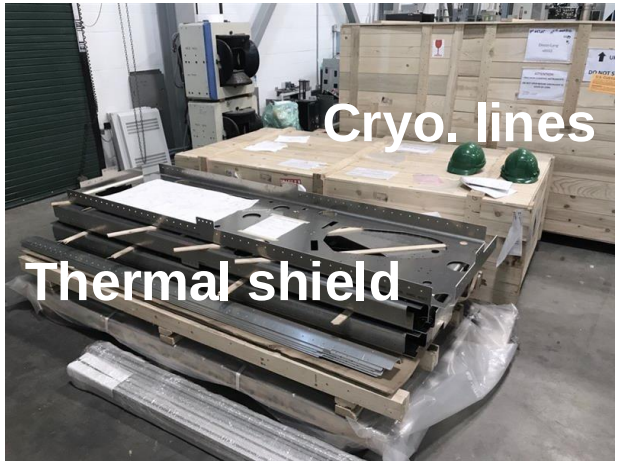




Cryomodule Fabrication

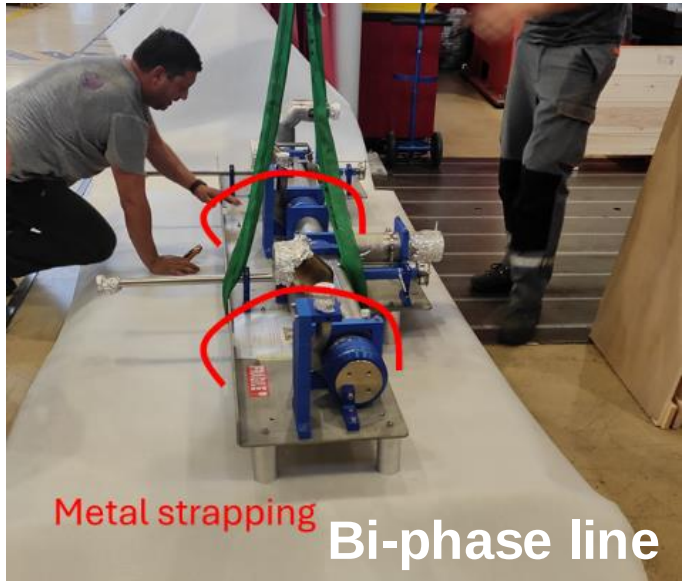
- Outer vacuum chamber (OVC)
  - Manufacture at Axton (Vancouver)
  - First article to be delivered in June, 2025
- Completed procurements for series
  - Warm magnetic shield (WMS)
  - Thermal shield
  - MLI
  - Tuner frame
  - Bi-phase supports
  - Cavity supports
  - Lifting blocks

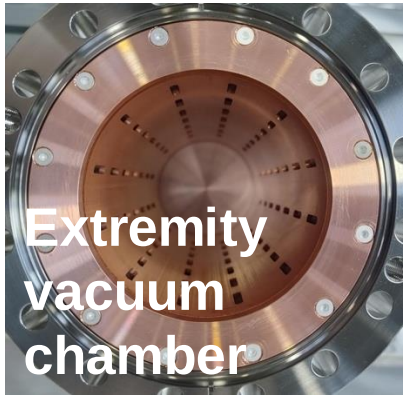


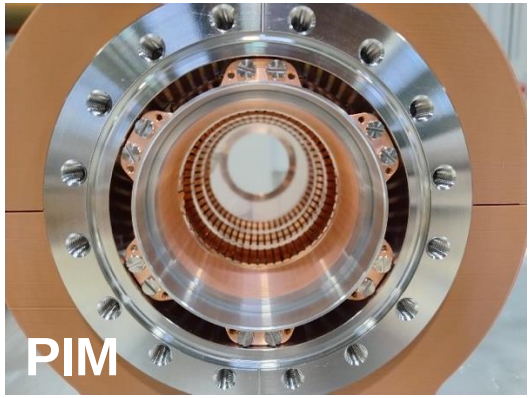


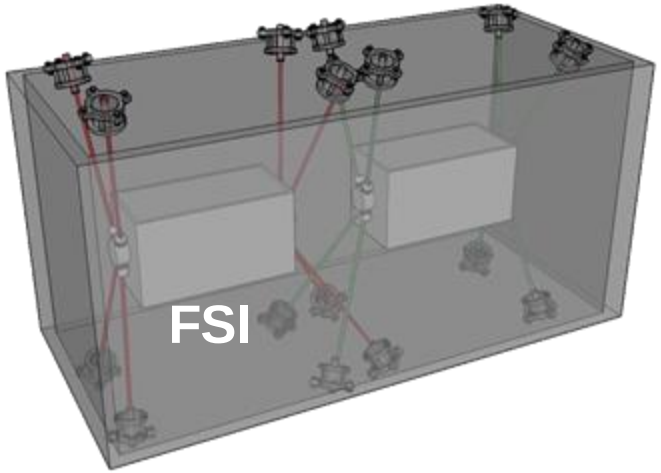
Deliveries from CERN

- Cryogenic lines including Bi-Phase line for 2 CMs
- Sector valves for 5 CMs
- Beam screens for 3 CMs
- Extremity vacuum components for 1 CM
- Plug-In Modules (PIMs) for 1CM
- Frequency Scanning Interferometry (FSI) components for 1 CM



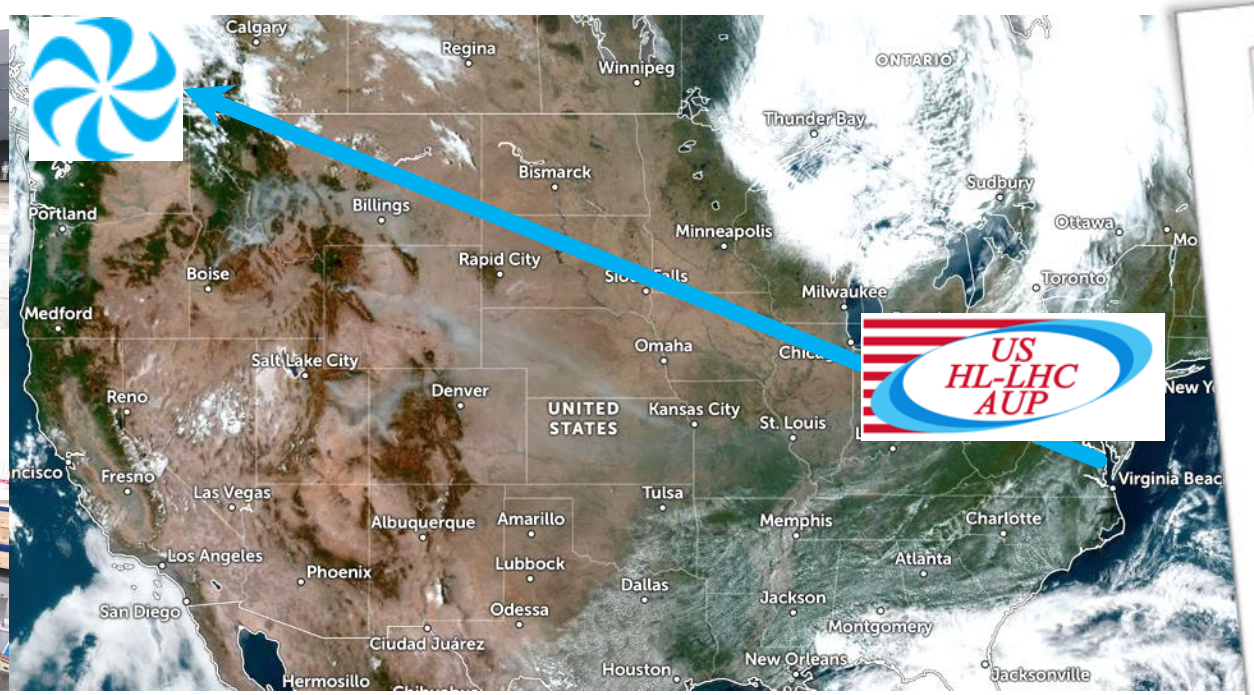


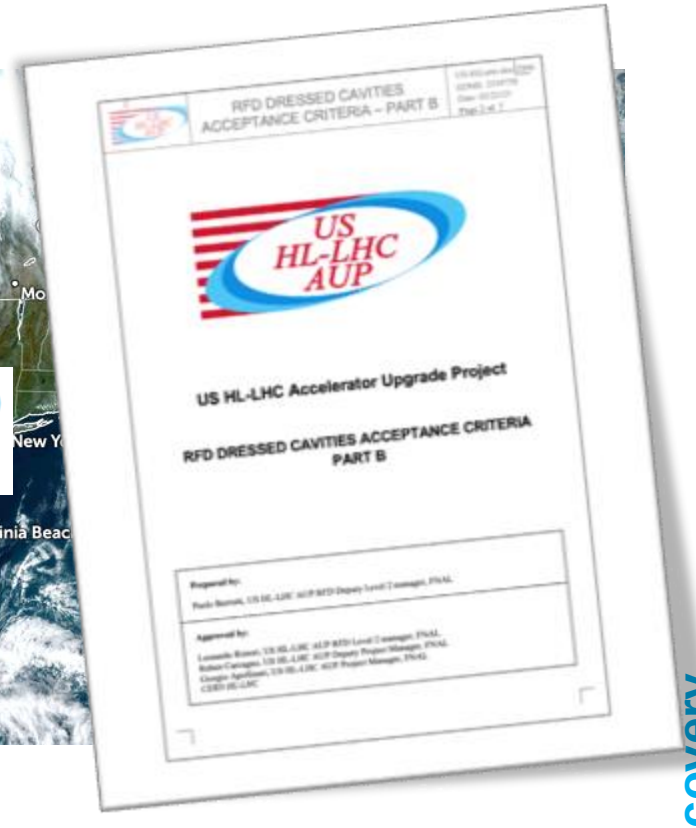




Cavity Re-Qualification

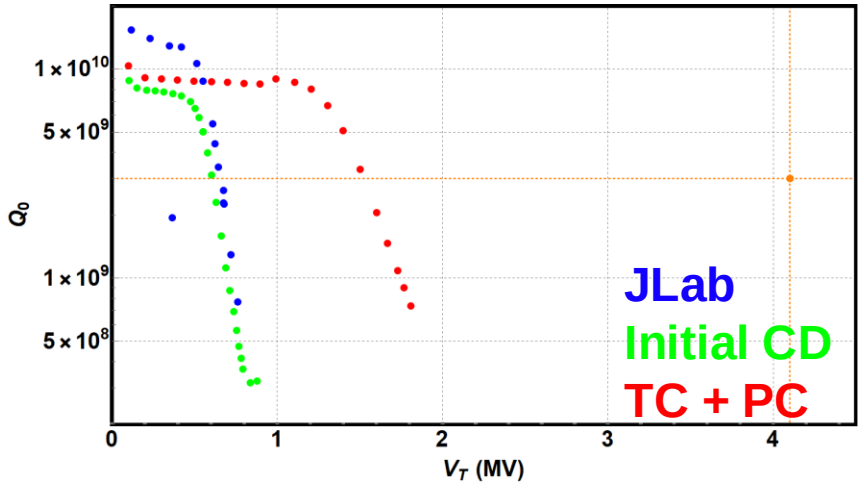
- TRIUMF will receive qualified dressed cavities from AUP under vacuum and requalify cavities upon arrival
- TRIUMF upgraded the cavity test facility to test dressed RFD cavities at 2K in jacketed mode

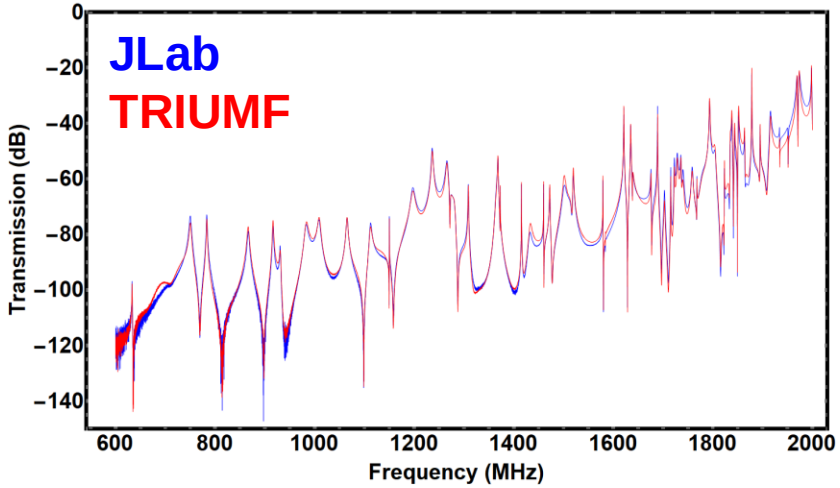




Cavity Re-Qualification

- TC0 cavity re-qualification test was successfully completed in March, 2025
  - Results are well matched to JLab results at both warm and cold
  - No performance degradation was observed after coast-to-coast shipment
  - New TRIUMF infrastructure worked very well
  - 4K and 2K cooldown were straightforward





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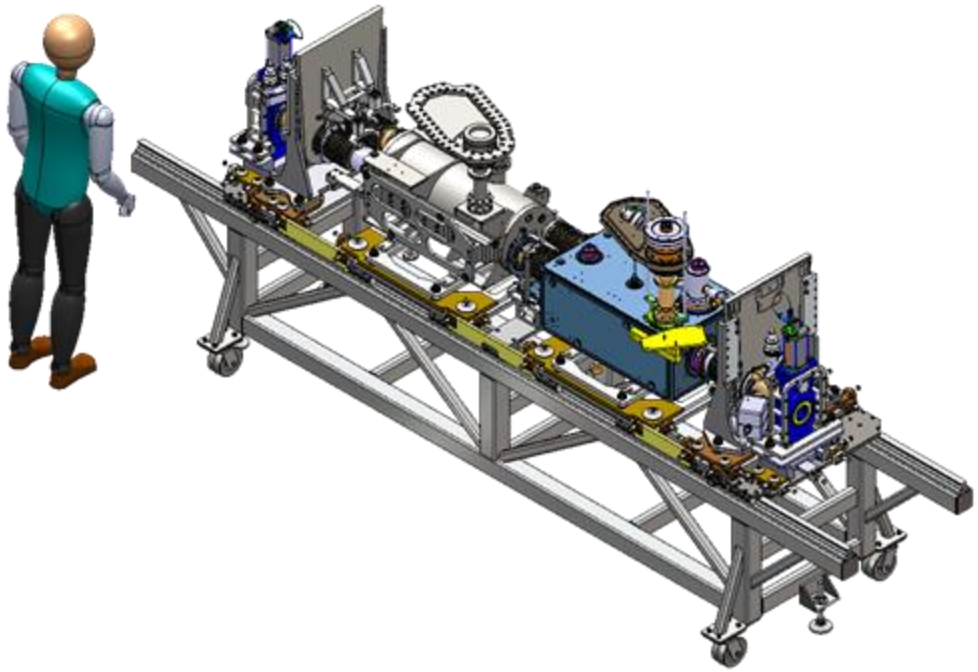
TCM0 String Assembly

- To complete string assembly with TC0 cavity and dummy cavity in new cleanroom
  - Receive and qualify cavity TC0 – completed
  - Assemble TCM0 string – to start in May 2025
  - Requalify TC0
  - Rinse TC0 and requalify
- Essential to confirm tooling, fixtures and procedures are 100% ready for series CM assembly



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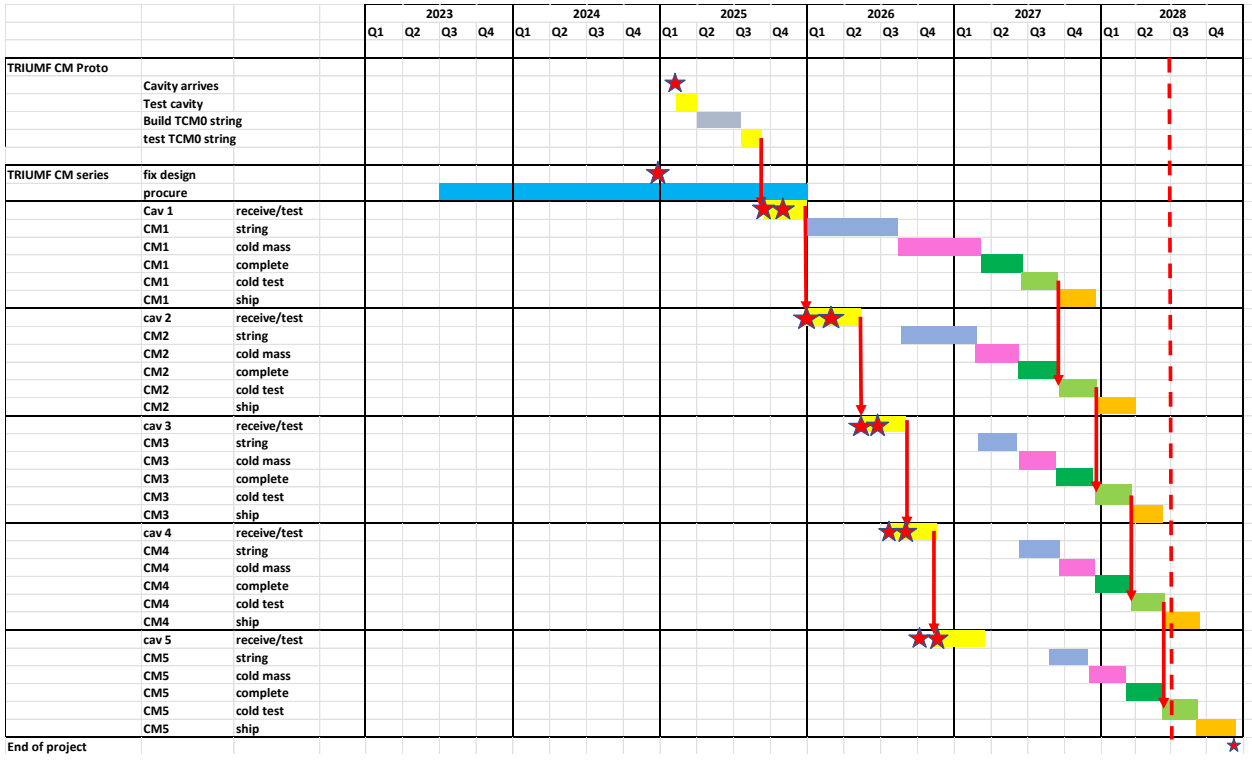
Series CMs Assembly

- CM fabrications have been well advanced
- Critical path runs through TC1 and TC2 cavities delivery
- Schedule has been adjusted to the new dates

AUP Delivery Projection		
Cavity Pair	**Module**	**Delivery**
Prototype TC0	TCM0	Feb 2025
TC1,2	TCM1	Oct 2025
TC3,4	TCM2	Feb 2026
TC5,6	TCM3	June 2026
TC7,8	TCM4	Sept 2026
TC9,10	TCM5	Nov 2026



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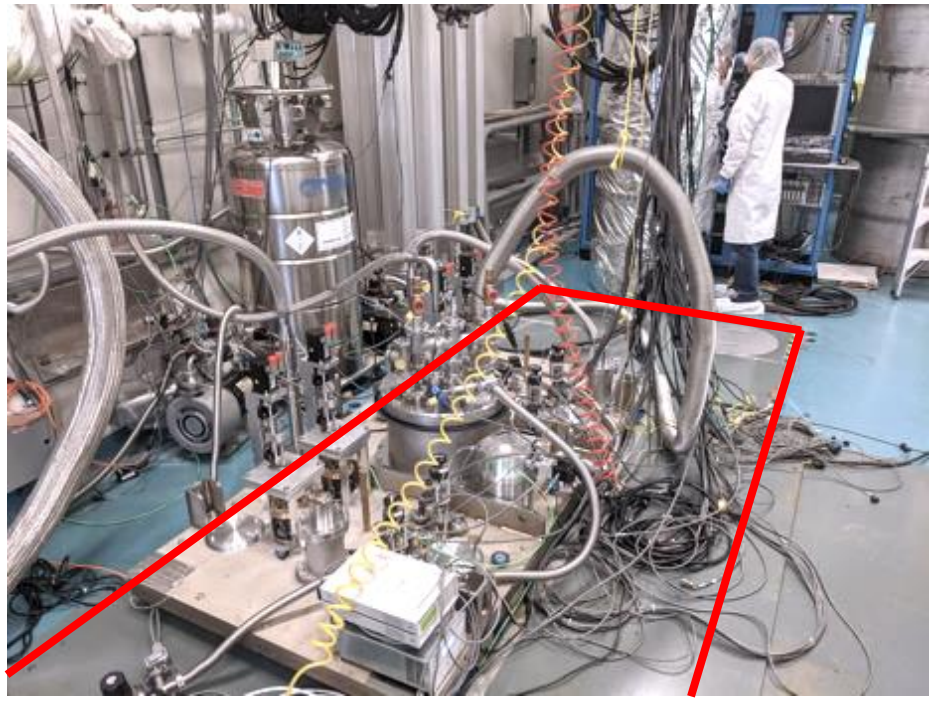
CM Qualification Test

- RFD cryomodule will be cold tested at TRIUMF prior to shipping to CERN
  - To partially verify CM functionality and performance at 4K
  - Requirements specification is under discussion



Summary

- Infrastructure upgrade and fixture/tooling manufacture for CM assembly have been almost completed and commissioned
- CM fabrications have been 95% issued, 50% have arrived
- TC0 cavity has been received and requalified, TCM0 string assembly is scheduled from May, 2025
- Series CM assembly schedule has been adjusted to accommodate AUP and CERN schedule
- TRIUMF Hi-Lumi team is transferring from the procurement mode to the technical mode

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Thank you
Merci
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