



Status of WP4 Crab Cavities & RF

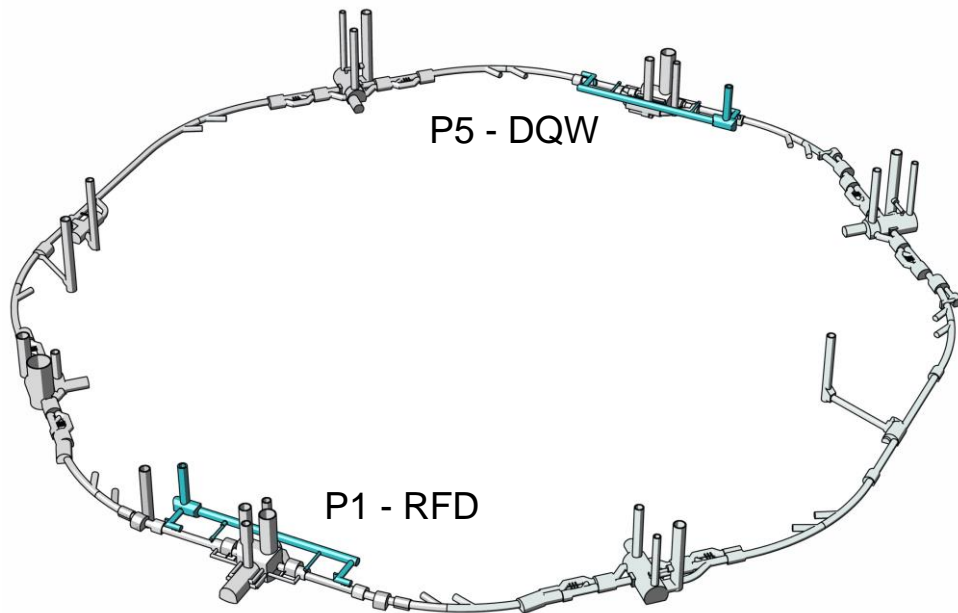
HL-LHC WP4 & Collaborations

CERN

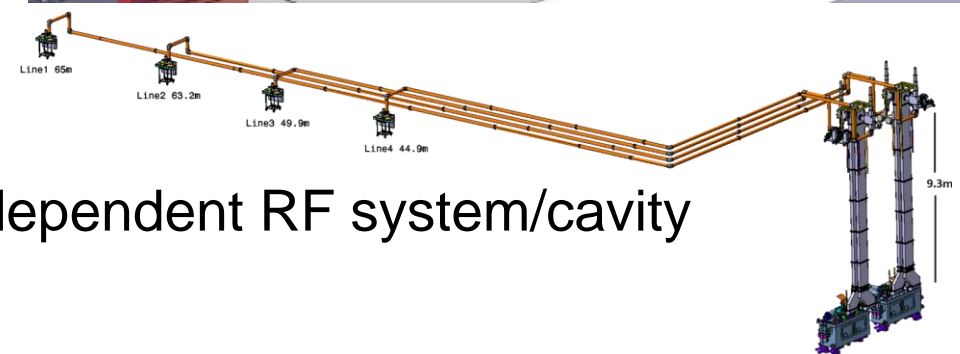
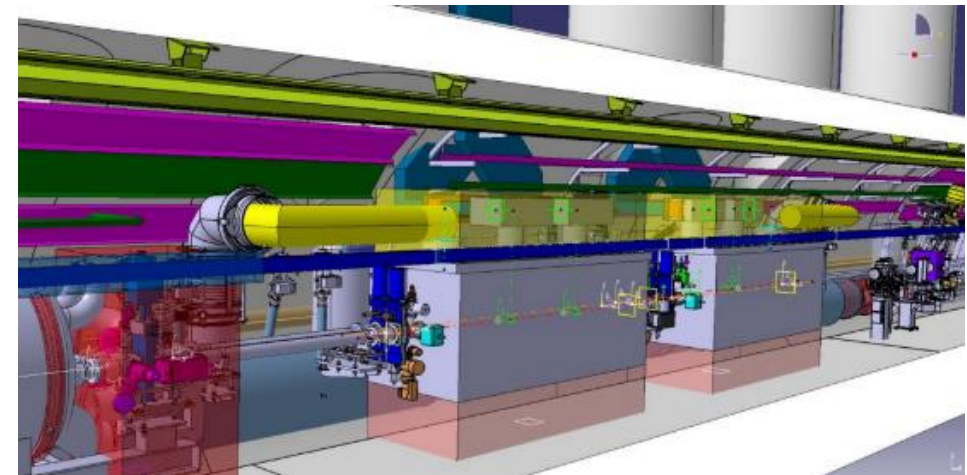


HL-LHC Crab Cavities

- 16 Superconducting compact RF deflectors (ATLAS + CMS) to partially compensate the geometric angle of $\sim 600 \mu\text{rad}$ and maximize the luminous region



One IP side
(4-cavities)



Independent RF system/cavity



Timeline, Crab Cavities

← HPRF/LLRF system not shown below →

2018-2023	2023	2024	2025	2026	2027	2028
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DQW CM SPS-tests



RFD CM SM18



CERN-DQW series (x2)



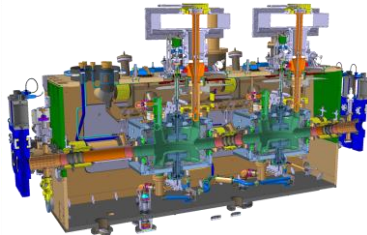
RI-DQW pre-series (x2)



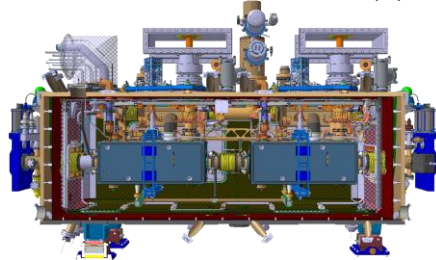
RI-DQW series (x6)



UK-CERN DQW CMs series (4 + 1)



Canada-CERN RFD CMs series (5)



USAUP-RFD pre-series (2)



USAUP-RFD series (10)

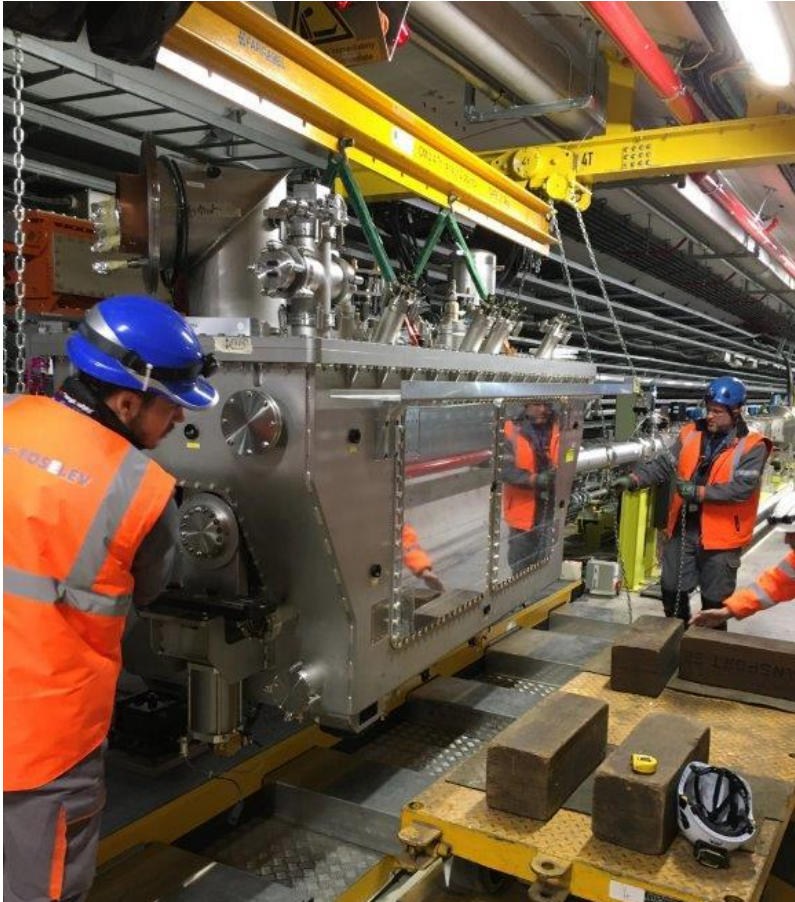


SPS-tests of Crab Cavities

- Test one module of each type (DQW & RFD) with protons
 - **DQW** module: 5 yrs of successful operation many [lessons learned](#). De-installed in 2023/24 YETS
 - **RFD** module: First cryomodule jointly with UK in 2023. Undergoing 2K tests in SM18, foreseen for SPS installation in Jan 2025



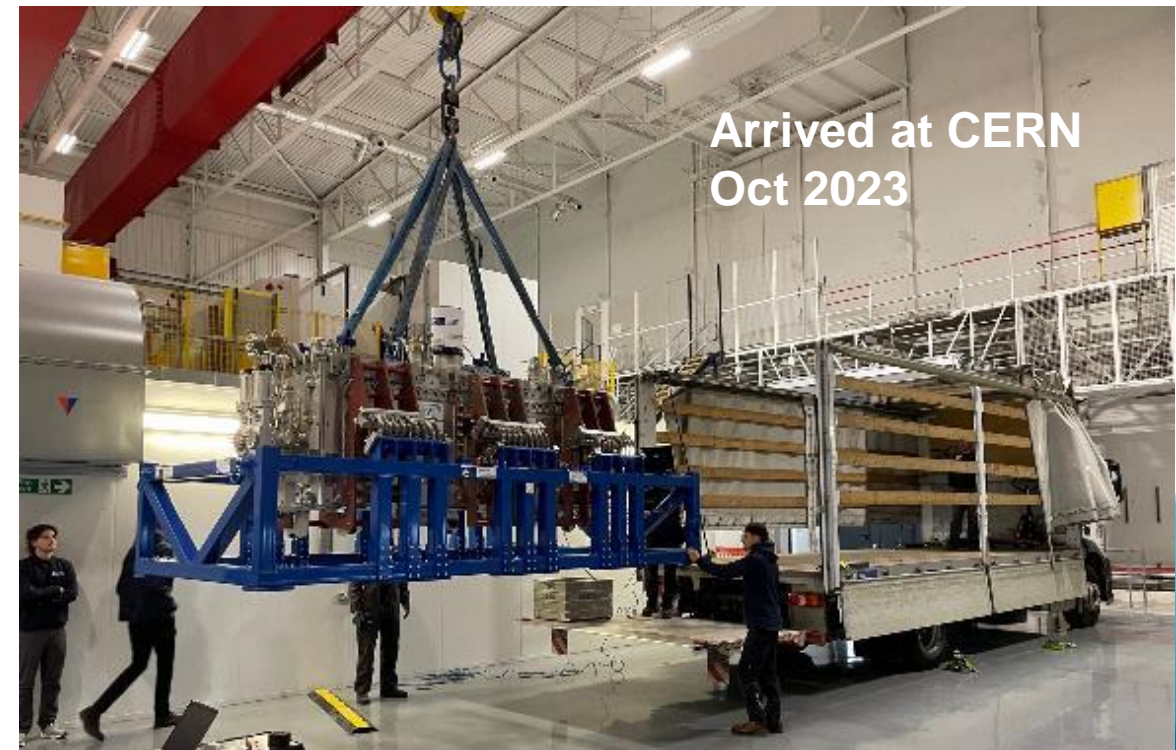
De-Installation of SPS-DQW, Nov 2023



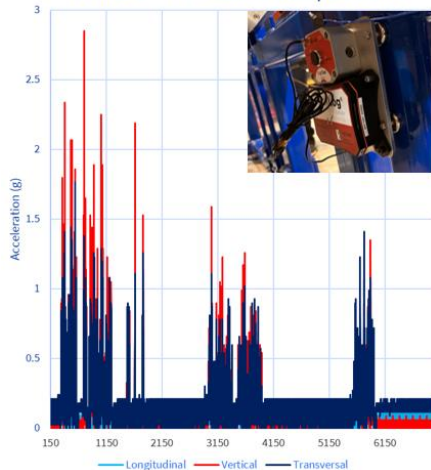
RFD-CM Prototype Transport (UK to CERN)



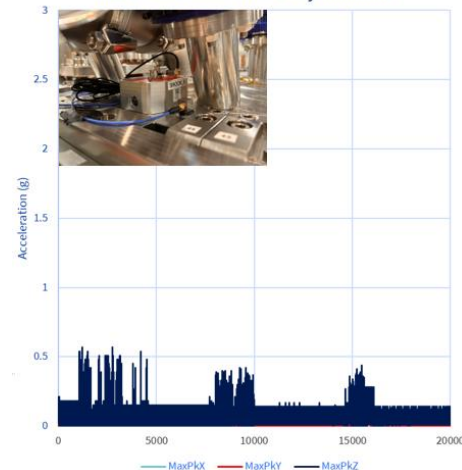
Successful transport with shock log & continuous vibration monitoring & strain measurements (see parallel session talks - Wed)



Events overview on the transport frame

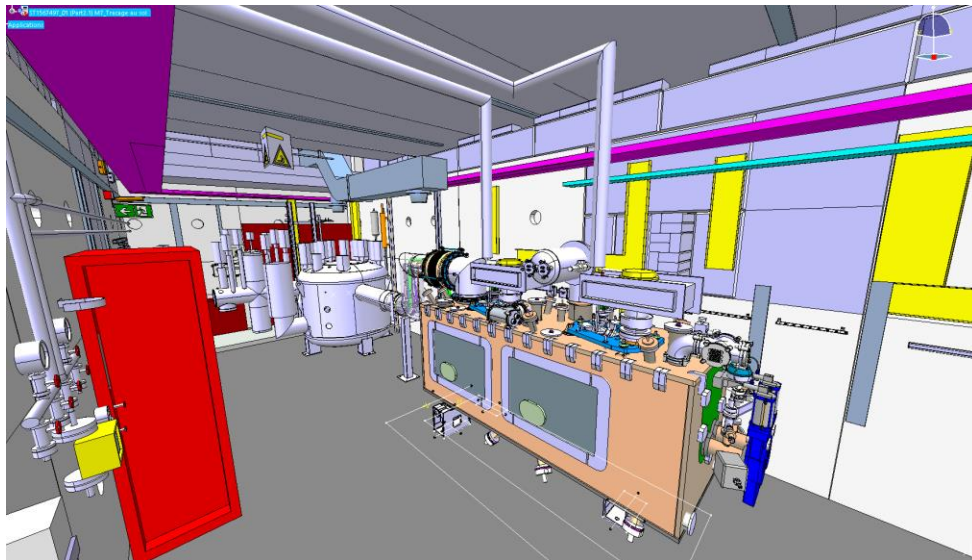


Events overview on the cryomodule



Cryomodule tests in SM18

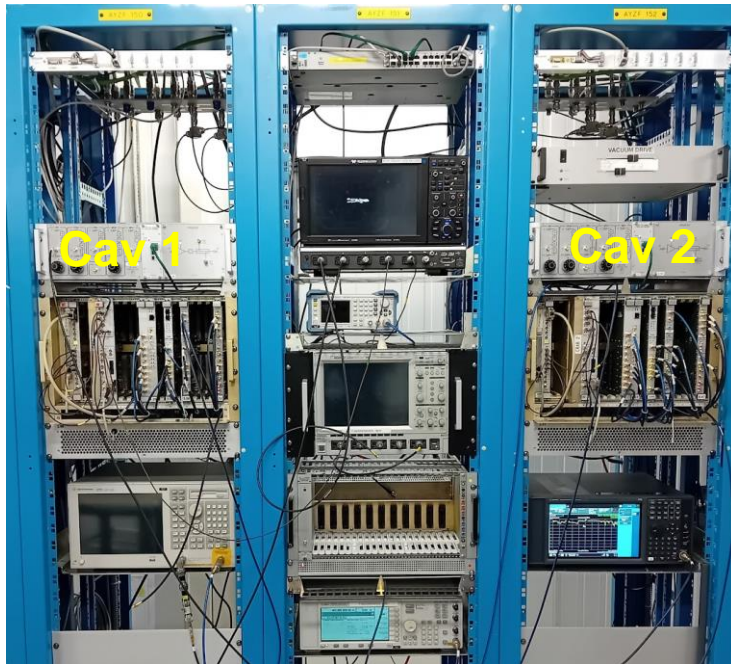
- SM18 infrastructure was prepared since 2023 to accept the RFD & series crab cavity modules. Installation done in Nov 2023
- A 6-month repair campaign on the couplers was necessary due to critical non-conformities (Tue morning session)



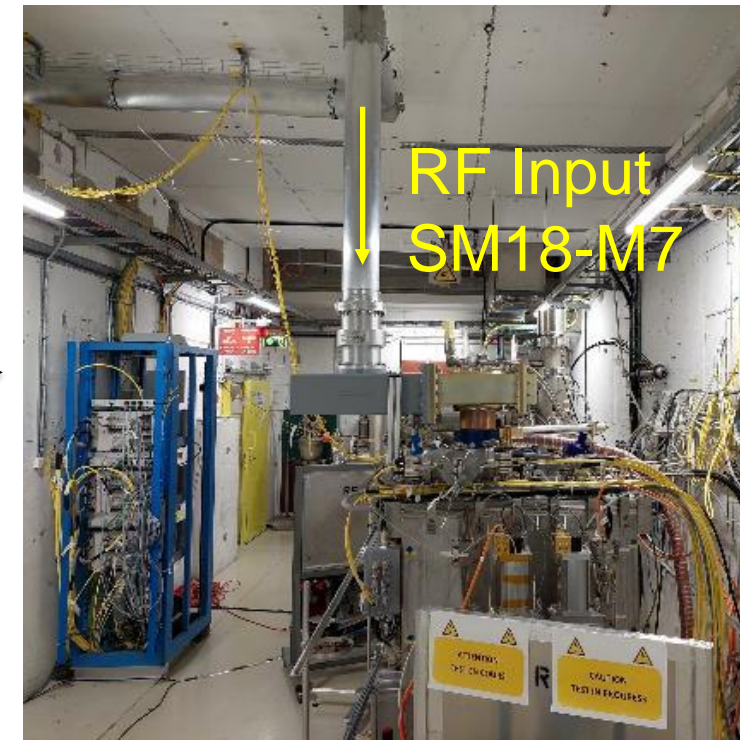
HPRF/LLRF System in SM18

- RF amplifiers were moved from SPS to SM18 for the CM tests. Up to 40 kW peak injected & cavities controlled on SPS cycles

LLRF system in SM18-FC

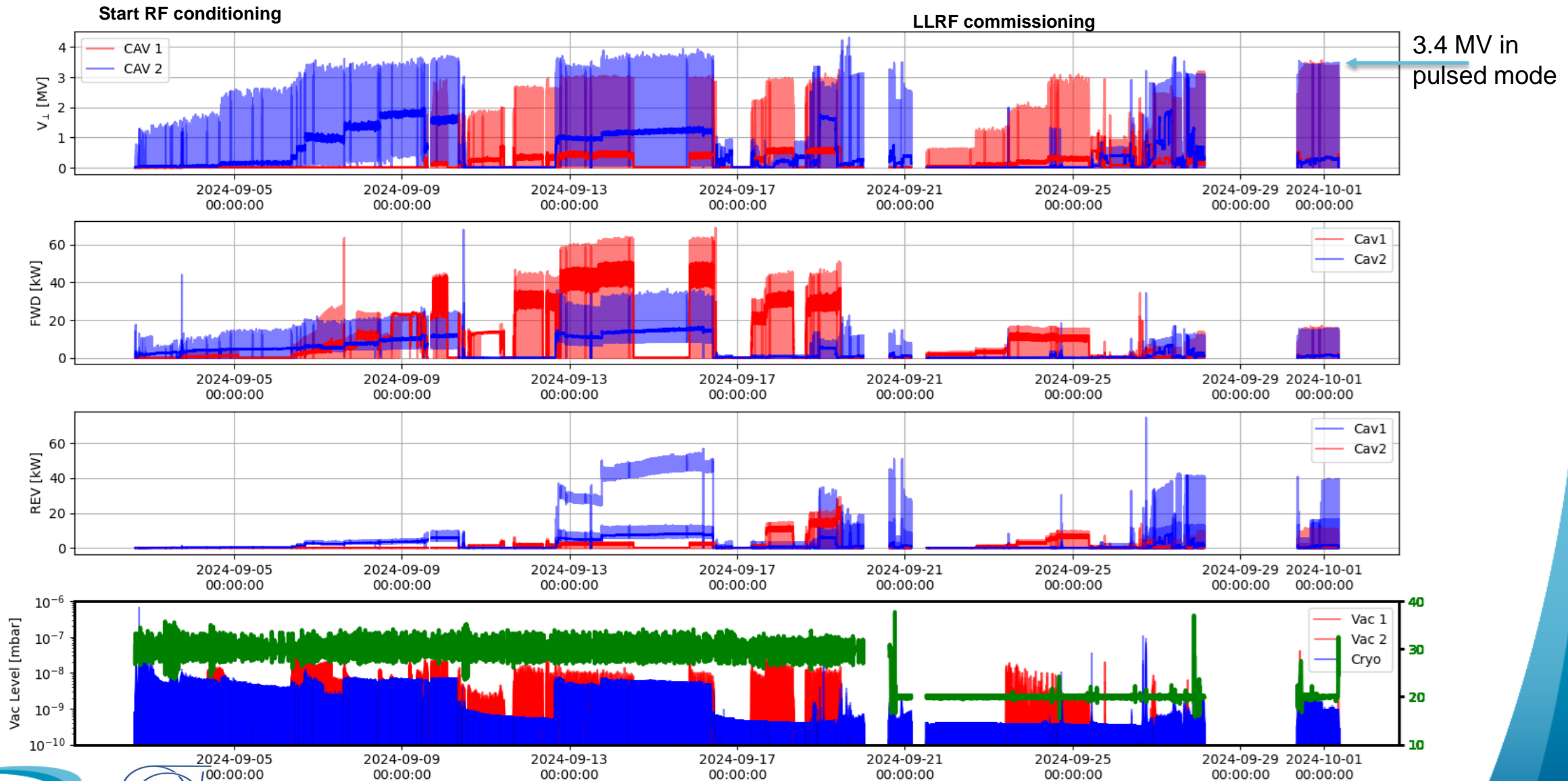


RF Amplifiers & Circulators



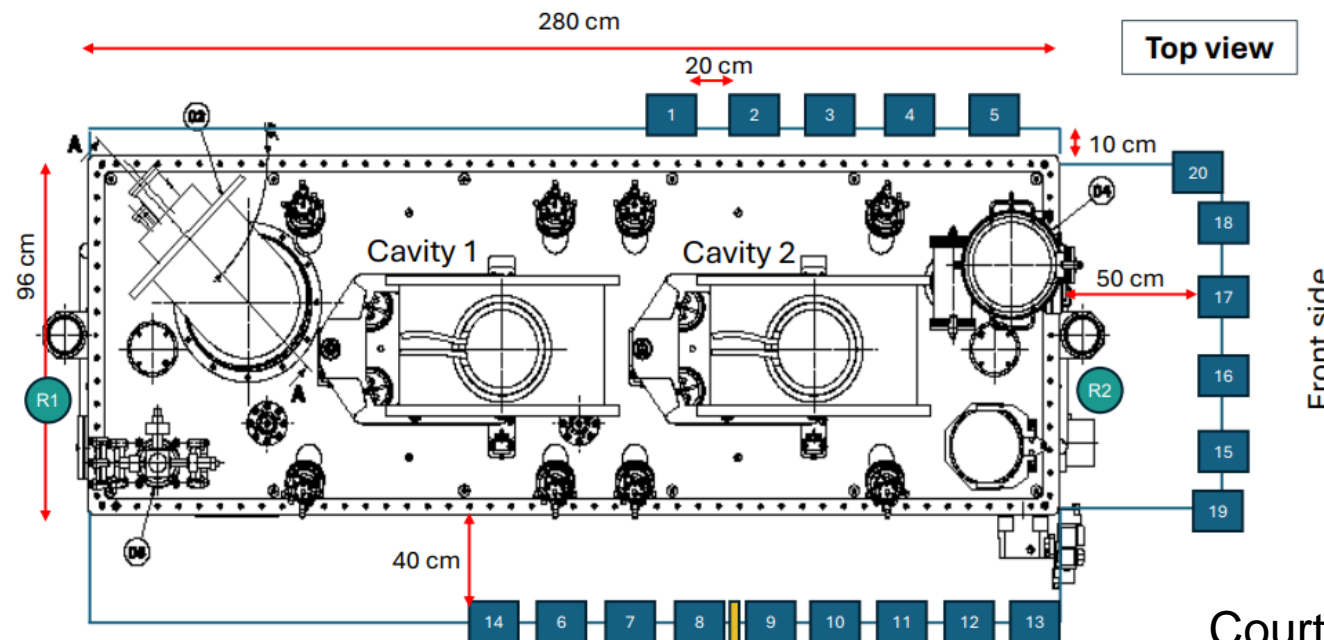
400 MHz IOT (60 kW-CW) & RF chain

RFD-CM Commissioning (Sep 2024)



Radiation Measurements in SM18

- A first attempt to map the radiation from x-rays emitted at high field is being carried out in collaboration with RP
- Eventual goal is to help sectorize the “no access zone” during RF conditioning in HL-LHC P1/P5



Courtesy: CERN-RP

WP4 Series Strategy & Procurement

Wed WP4
parallel sessions

5 DQW cryomodules (Europe)

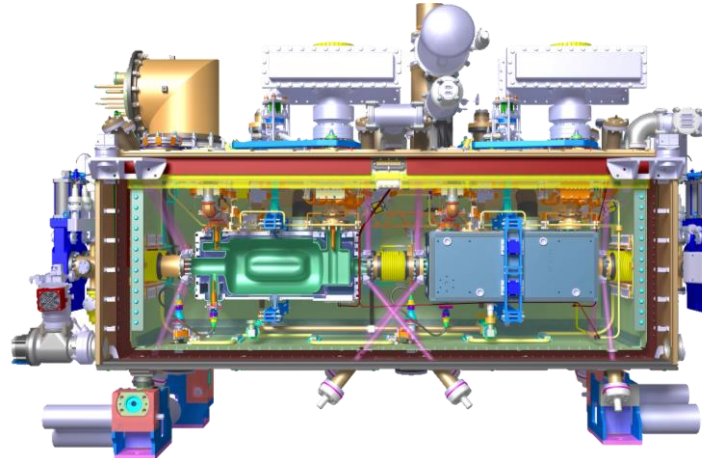
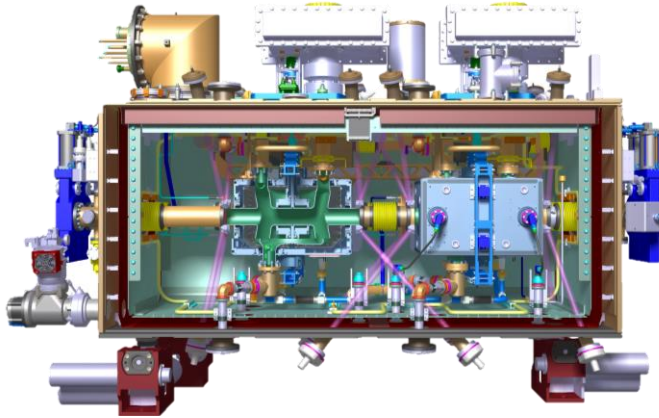
- Cavities + processing + helium vessels by Research Instruments (DE) & CERN
- Cold magnetic shields by UK
- HOM couplers + antennas by CERN
- 4 CM by UK (STFC) & 1 CM at CERN with some components from CERN
- All cavities & CM cold validation tests at CERN (and a back up at Uppsala-Sweden)

5 RFD cryomodules (North America)

- Bare cavities by Zanon (IT) under US-AUP
- Processing + cold magnetic shield + helium vessel + HOM couplers + antennas + cold tests by US-AUP/CERN
- 5 CM by TRIUMF-Canada with some components by CERN
- CM cold validation tests at CERN

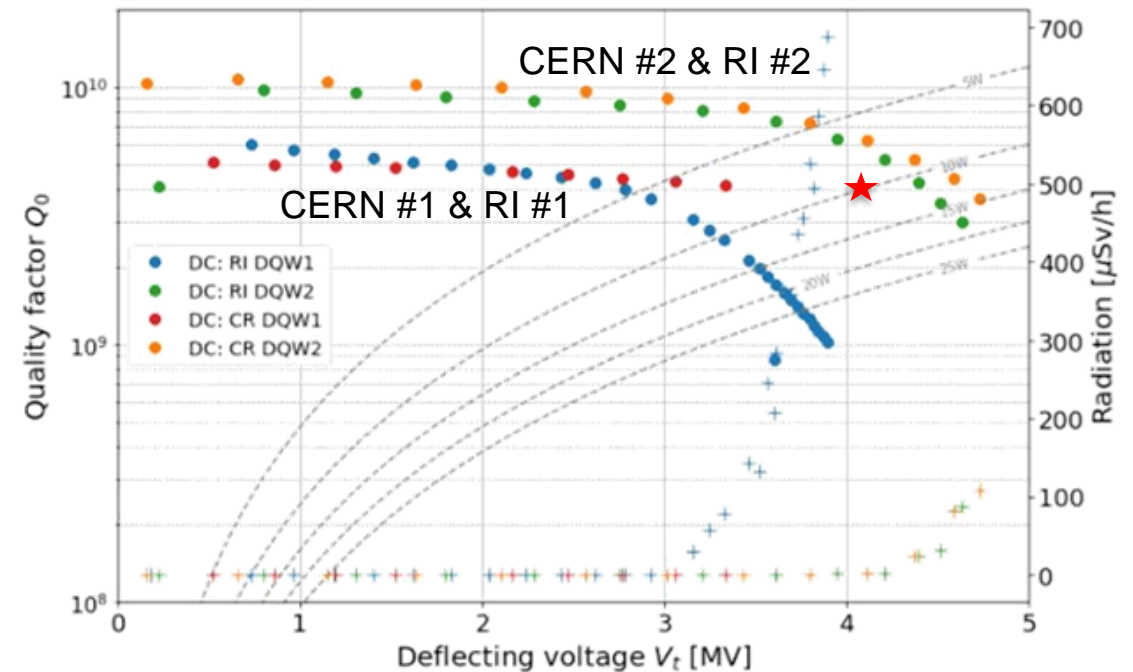
20 RF Systems (Asia, CERN)

- High power amplifiers (IOT) CERN-KEKB
- High power RF lines, circulators, loads by CERN-KEKB
- μ TCA platform for LLRF by CERN



DQW, Series Cavities

- Two dressed cavities (CERN #2 & RI #2) qualified well beyond specification, shipped to UK-STFC for cryostating
- Two dressed cavities slightly limited in performance, re-testing ongoing



DQW Series Cavities & Ancillaries

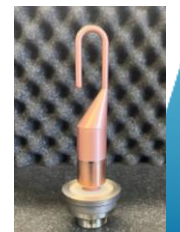
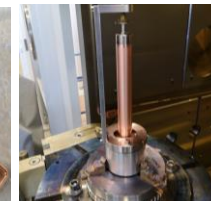
Tue/Wed WP4
parallel sessions

- Next series cavities (RI #3 & #4) completed. Accumulated some delays due to issues on welding
- RI #5-#8 in the final welding stages, to be completed mid-2025
- CERN fabrication of HOM couplers & FPCs progressing on track

RI-DQW #3



RI-DQW #4

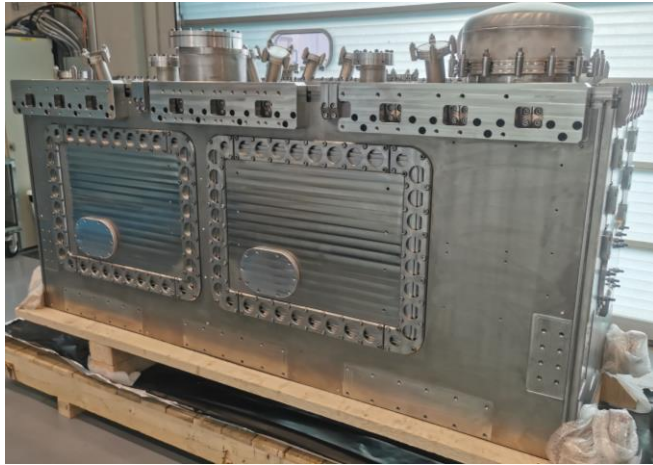


Series Production, CM Components

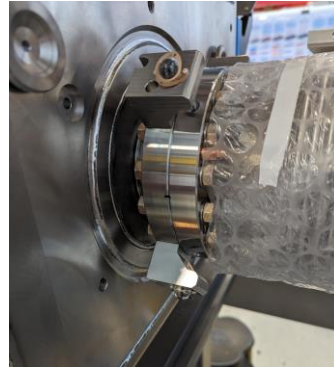
Wed afternoon WP4
parallel sessions

Series procurement & manufacturing in full swing for CERN-CM and for collaborations

Outer Vacuum Vessel for CERN-DQW



Alignment equipment

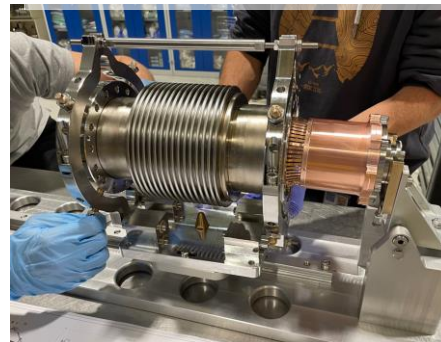


Cryolines for TRIUMF

Beam Screens crab series



PIMS & RF Fingers



Pumping crosses

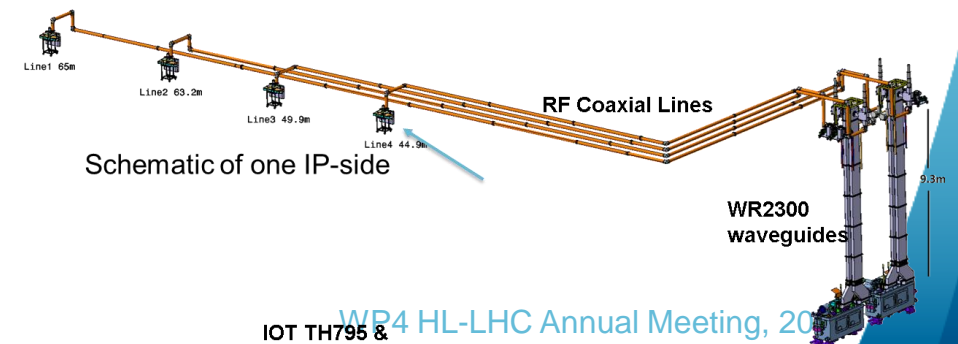
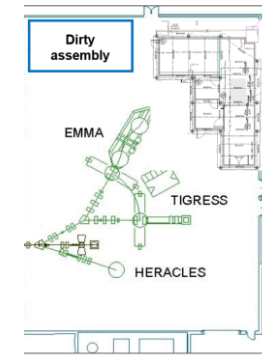


Wed afternoon WP4
parallel sessions

Collaborations

Tue/Wed WP4
parallel sessions

- UK-STFC
 - Two series DQW cavities sent to UK-STFC & first series cryomodule assembly started
 - Several infrastructure upgrades done and procurement in progressing well
- US-AUP
 - Two pre-series cavities completed. First cavity successfully tested, rest of series in the pipeline
- TRIUMF-Canada
 - Procurement of major cryomodule components for TCM0 & series in full swing. Infrastructure upgrades in final stages
- KEK-Japan
 - Confirmation of in kind from Japan Dec 2023 ([KR5904](#) [SYADD5](#) [RFCC](#)). Market survey being launched via CERN procurement



Next Steps

- RF Dipole Prototype: SM18 validation in the final stage, installation SPS machine in Jan 2025, will complete the crab cavity validation phase with beam
- Series cavities to be completed by the end of 2025, cryomodules between 2025-2027
- HPRF & RF Controls procurement between 2025-27, installation in the UA galleries as units received at CERN

Special Thanks

After 33+ years at CERN, Eric Montesinos will retire at the end of this year.

Since 2008 he was actively working on crab cavities, where he brought his vision, passion and dedication on RF couplers & high-power RF to always push beyond the cutting edge.

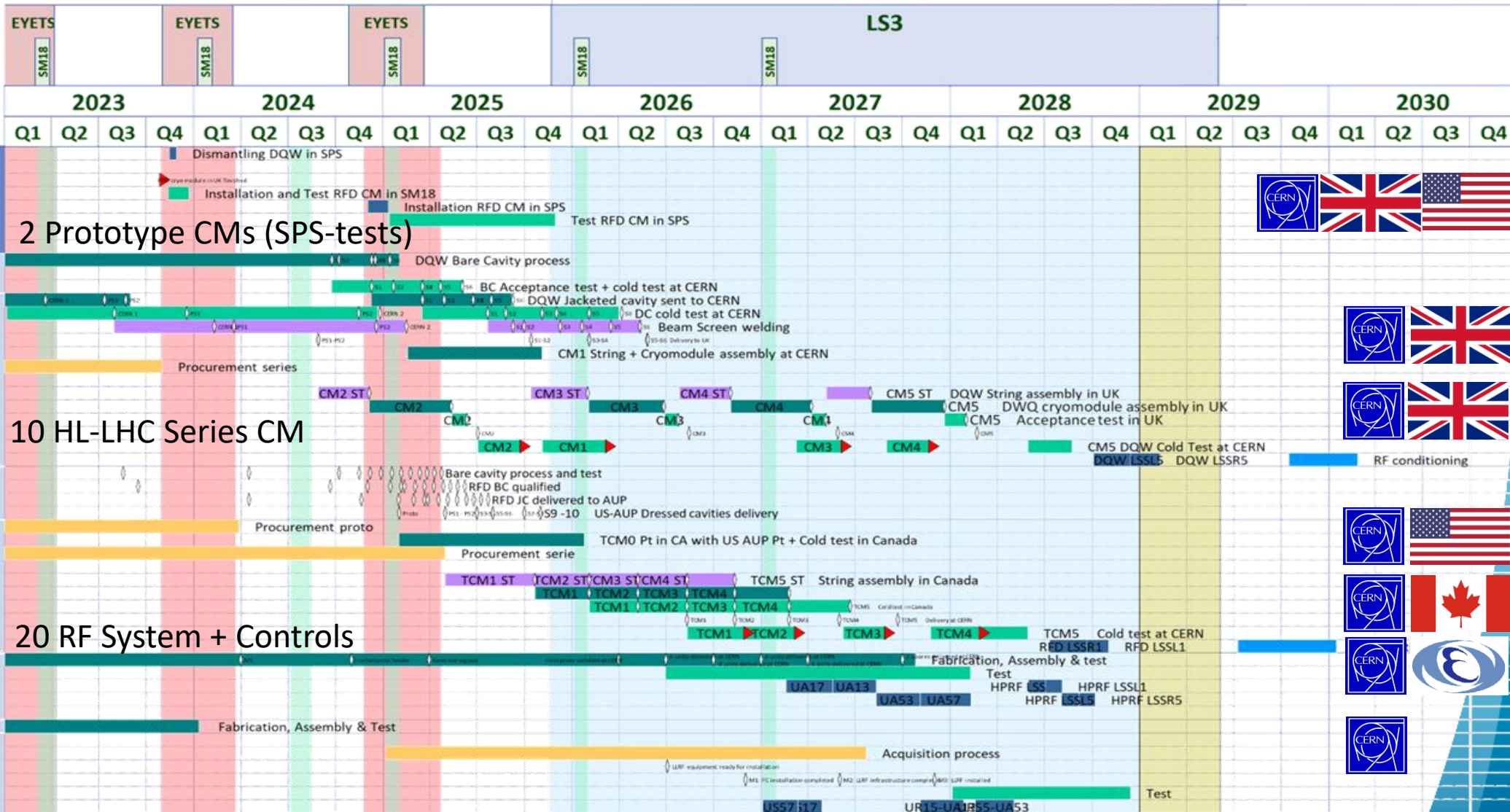
Thank you Eric!

Wish you the best for your next adventures.



Master Schedule, WP4

LS3 Reference Schedule (ACC-PM-MS-0004)



WP4 - In work for CSR2024



Specifications Assembly IFabrication Test Installation Installation Spare Milestone Output