



RFD-CM reception at CERN & acceptance tests

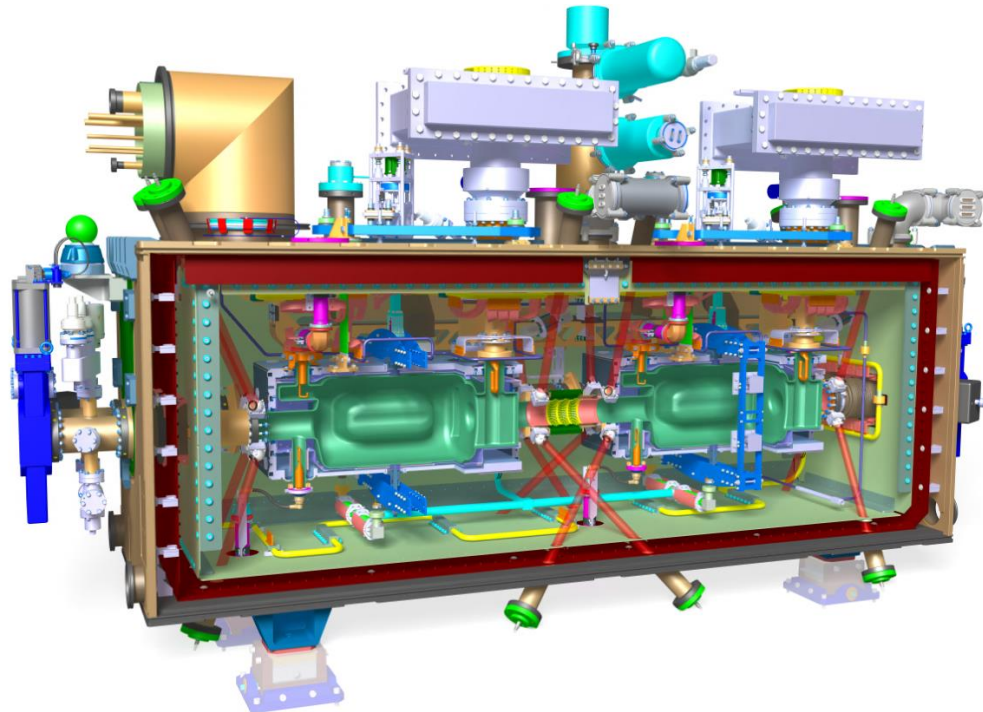
Katarzyna Turaj & Nuria Valverde
on behalf of WP4 and SRF team



12th HL-LHC Collaboration Meeting, Uppsala, 19-22.09.2022

Outline

- Goals of RFD cryomodule cold test
- Infrastructure
- Preparation and test program
- Conclusions

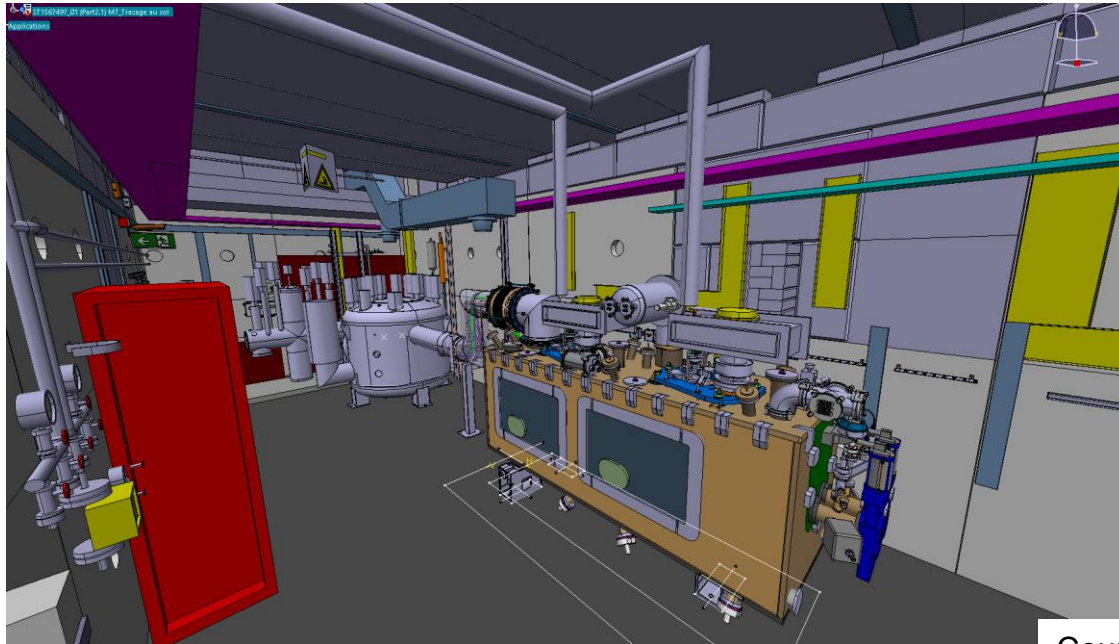


Courtesy: T. Capelli

K. Turaj, 21st September 2022

Goals of RFD CM cold test in SM18

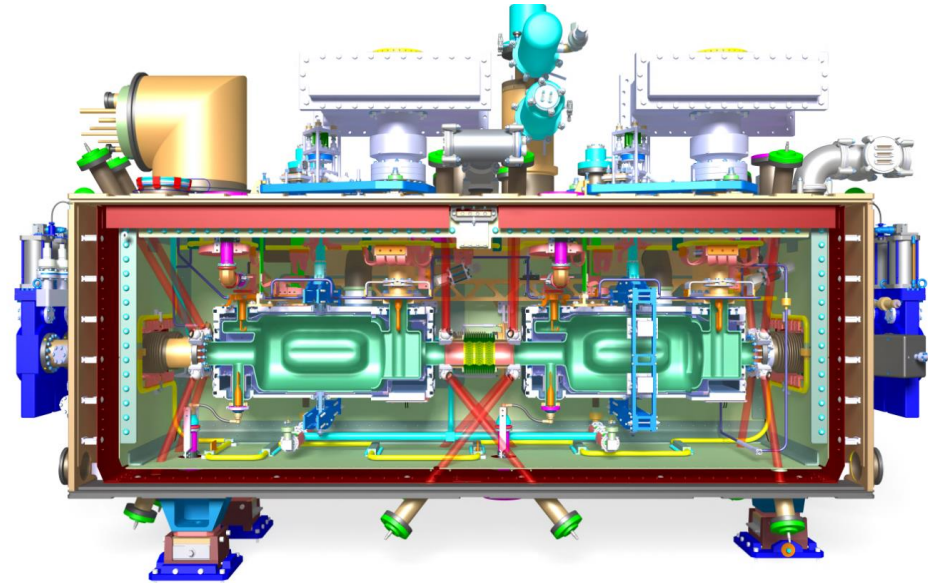
- RF testing of RFD CM is foreseen as a crucial validation step of the cryomodule assembly process.
- A full validation of the cryomodule at 2K is required before RFD CM can be installed in the SPS.



Courtesy: A. Kosmicki

RFD CM parameters

- Voltage 3.4 MV/cavity
- Epeak 40 MV/m
- Bpeak 70 mT
- Frequency 400.79 MHz
- Q_0 10^{10}
- Q_{ext} 5×10^5
- Cavity tuning ± 100 kHz
- Temperature 2.0 K
- RF power 40 kW



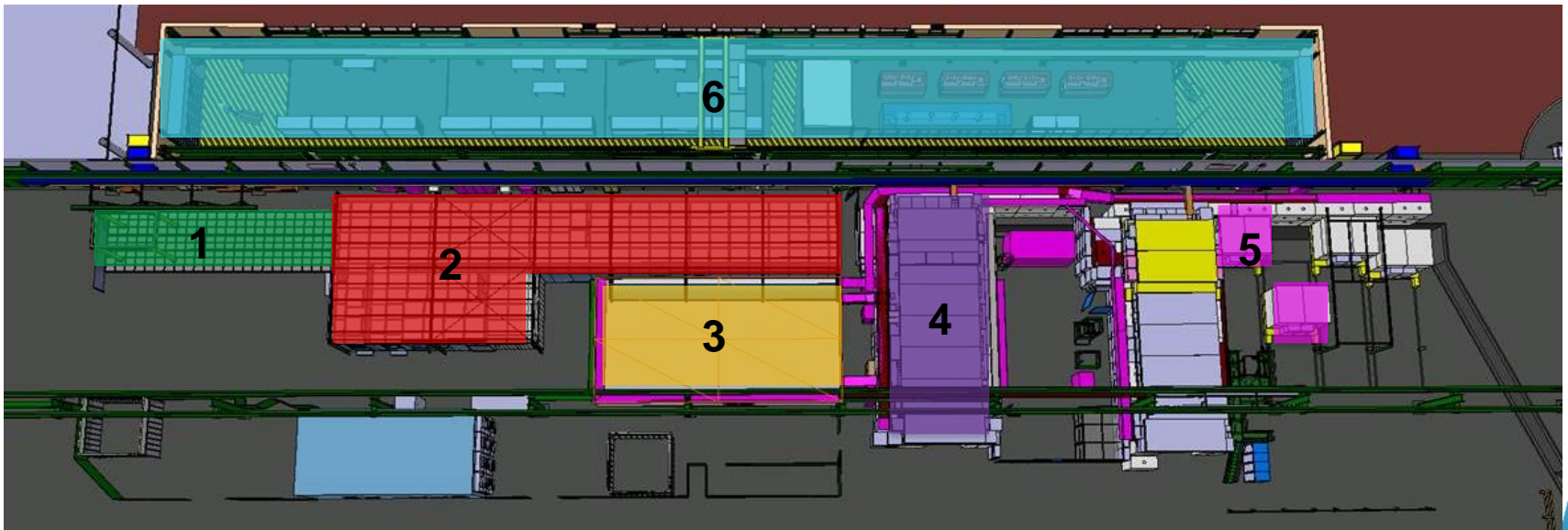
Courtesy: T. Capelli

Eng spec. 2043014

K. Turaj, 21st September 2022

SM18 Test & Assembly facilities

- 1 External rail system: Cryostating
- 2 Clean room: ISO4, ISO5, HPR cabinet
- 3 Control room: Measurement test stands
- 4 Horizontal bunker: Cryomodule Test
- 5 Vertical cryostats: V3 & V4 for testing of bare and dressed cavities
- 6 Extension: ~600 m² of the reception and storage space



Infrastructure: M7 test stand

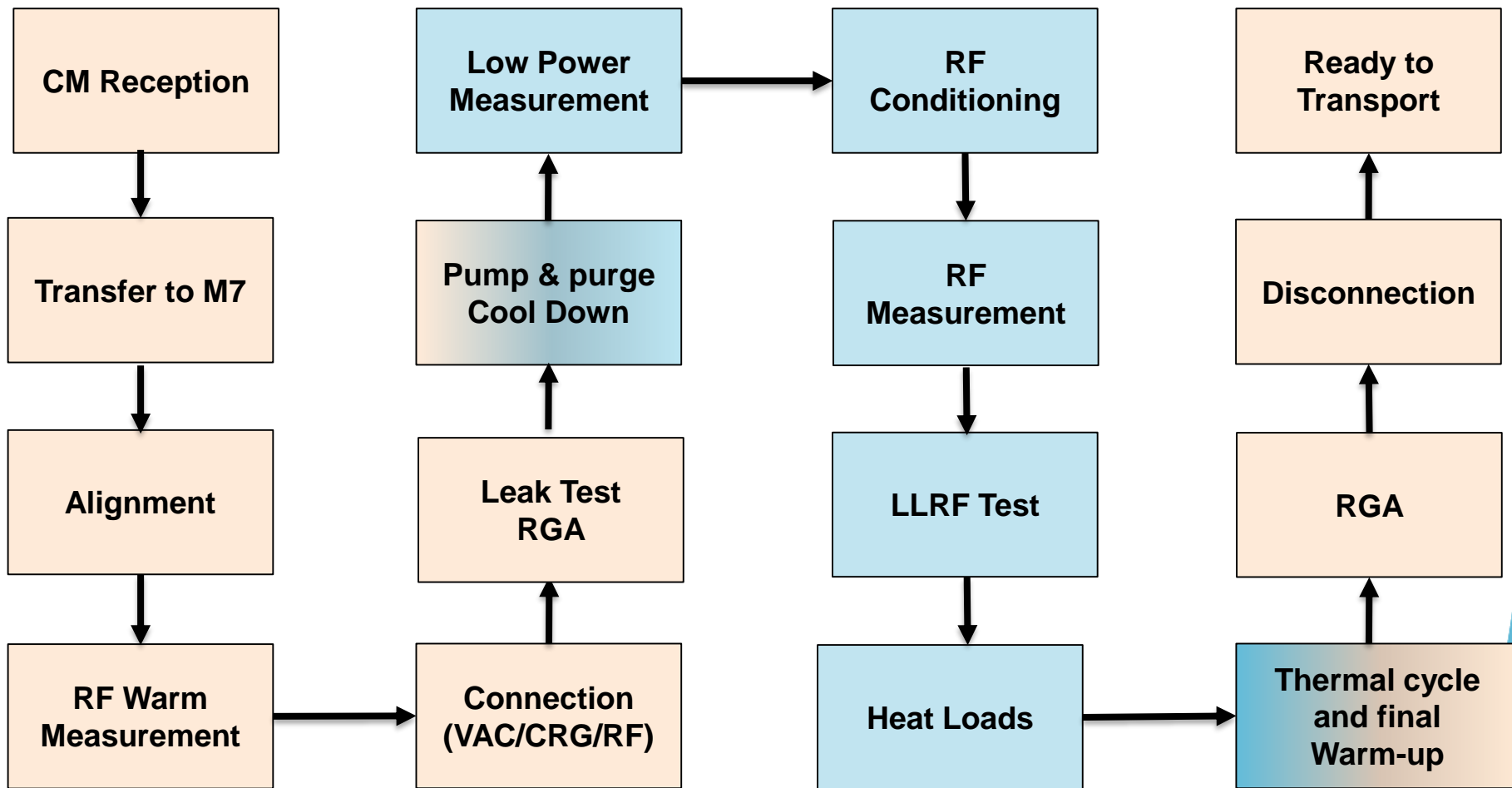
- Dedicated bunker M7 to allow full validation of CM.
- Used in 2016 for DQW-SPS CM test but requires some updates and missing hardware installation.
 - HPRF: → see E. Montesinos's talk
 - 2 IoTs: 400 MHz / 40 kW cw – 80 kW peak
 - LLRF:
 - 2 VME crates: Crate Manager, Cavity Loop, SWAP, Tuner Loop, Clock Distribution
 - Controls system and software:
 - Fast interlocks, PLC power and tuner control, FESA classes
 - Cryogenic infrastructure: → see K. Brodzinski's talk
 - 2K operation
 - Vacuum system: → see C. Pasquino's talk
 - Insulation, beam cavity vacuum and 2nd beam line
 - Radiation monitoring system
 - Alignment monitoring system → see V. Rude's talk
 - User interface and data logging

RFD CM Test Program

- Manufacturing and Inspection Plan : CRAB RFD CM TESTING SM18 → EDMS 2756481

| Tests (Eng. spec. EDMS2043014) | Comments |
|---|--|
| RF Frequencies of deflecting mode | RF VNA measurements (after string assembly) Target frequencies, 400 MHz: $S_{11} \leq -25 \text{ db}$, HOMs: $S_{21} \geq 0.25 \text{ db}$ |
| Q_0 - V_t curve including power dissipated at 4.1MV at 2K | Calorimetric measurements |
| Quench field value | |
| Lorentz Force Detuning test | |
| dF/dp test | |
| HOM frequencies & Q's | With particular care to frequencies around 760 MHz for RFD and 960 MHz for DQW |
| Output power through HOM coupler | |
| Test on modes around 760 MHz | |
| External coupling verification of ancillaries | External quality factor of several HOMs External quality factor of the field antenna (at fundamental mode frequency) |
| Field emission onset (Emitted radiation from cavity) | $< 50 \mu\text{Sv/hr}^2$ |
| Multipacting levels | Sustained RF full power within vacuum limit of $1 \cdot 10^{-8}$ mbar |
| Effect of thermal cycling (15K-2K) | 3 cycles. The variation of all the parameters in this table shall be within a range of +/- 5% |

Workflow of RFD CM in SM18



RFD CM Test Program

- After delivery, check of the transport monitoring system and visual inspection, the CM will be transported to the M7 bunker
- **Verification for the assembly at warm**
 - Dimensional controls
 - Vacuum vessel checks (welds and tightness)
 - Cryogenic instrumentation
 - Remove N2 level gauges and install He level gauges
 - Installation of He guards for safety exhaust line (safety valves, rupture disk and pressure measurements)
 - Vacuum instrumentation
 - Install insulation vacuum instrumentation
 - All vacuum connections will be done with temporary clean rooms
 - Only dry pumps
 - Instrumentation checks
 - Visual inspection and electrical continuity
 - RF checks and measurements
 - 400MHz and HOM modes including Qext meas
 - Tuner response vs frequency
 - Alignment check and measurements
 - Connection and test of adjustment system
 - Leak tests and RGA tests
 - Insulation vacuum, beam vacuum, 2nd beam line

RFD CM Test Program

- Interlock checks and safety test
- Cool down following Eng Spec.
 - RGA mass 4 during cool down
 - Thermalisation
- Alignment measurement at 2K
- Low power measurements at 2K
 - RF freq. measurement
 - HOM spectrum and Qext's
 - Check rejection of 400MHz in HOM
 - Tuner response
- RF conditioning (FPCs and cavities) at 2K
- RF cavity performance at 2K:
 - max field, vacuum activities, dynamic and static head loads measurement, radiation vs field curve, HOM power measurements, sensitivity to the pressure variation, tuning performance and heat run
- Thermal cycle
- RGA scan

RFD CM Test Program

- Warm-up
- Leak detection and RGA of cavity beam line
- Deformation measurement (3 vacuum cycles)
- RF 400MHz and HOM freq. measurement
- Clean disconnection of dry vacuum pumps
 - Cavity and 2nd beam vacuum actively pumped by the ion pumps
 - Insulation vacuum vented with N2
 - Logging of vacuum data
- Disconnection
 - Coax line, cutting the cryo lines, cables disconnection
- Storage in M7 bunker

Conclusion

- The test infrastructure is being prepared to allow full RFD CM validation
- A validation and test program is being developed
 - Including procedures, reports and full data logging

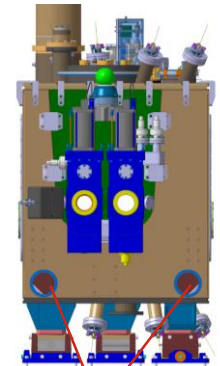
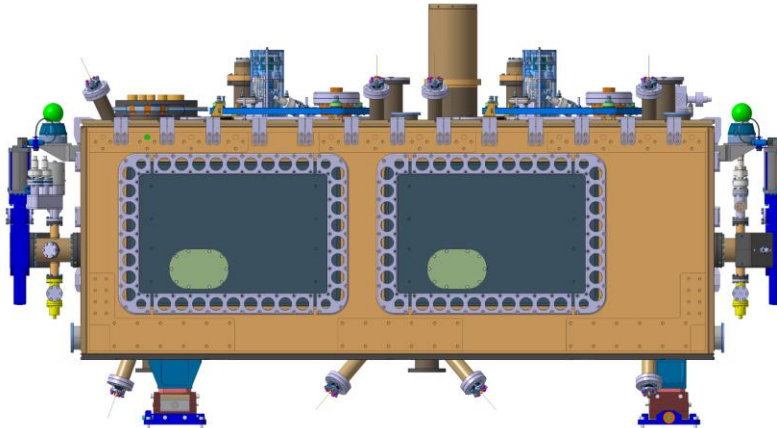
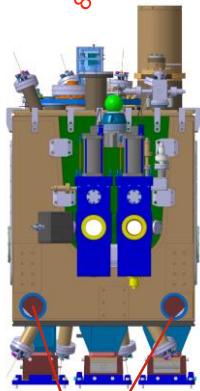
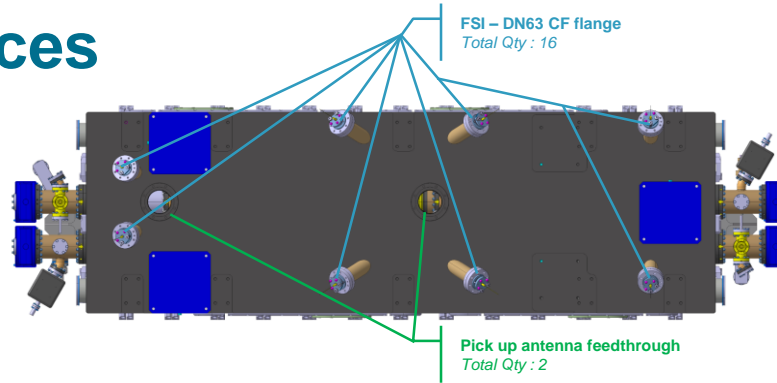
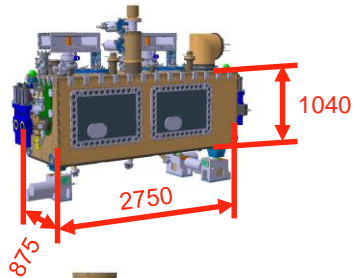


Thank you very much!



RFD cryomodule ports/interfaces

- RF connexions**
SY/RF
- Alignment and position monitoring**
BE/GM
- Insulation vacuum**
TE/VSC
- Beam vacuum**
TE/VSC
- Cryogenic**
TE/CRG



Insulation vacuum pumping port 1/2
Total Qty : 4- iso K DN100

Level gauges feedthrough
2x / 2x ConFlat (CF) DN40

FSI - DN63 CF flange
Total Qty : 16

Insulation vacuum pumping port 2/2
Total Qty : 4- iso K DN100

Cryogenic jumper
Iso K DN400
Total Qty : 1

Beam vacuum instrumentation 2/2
Total Qty : 4
See drawings XXXXX

Insulation vacuum instrumentation - Iso K DN100
Total Qty : 1

Beam vacuum instrumentation 1/2
Total Qty : 4
Drawing under preparation

Insulation vacuum pressure relief - Iso K DN160
Total Qty : 1

Instrumentation port
3 Flanges ISO K DN100

HOMS feedthrough
Total Qty : 4

Cryogenic safety port for pressure measurement
1 Flanges ISO K DN63

Instrumentation port
1 Flange ISO K DN100

