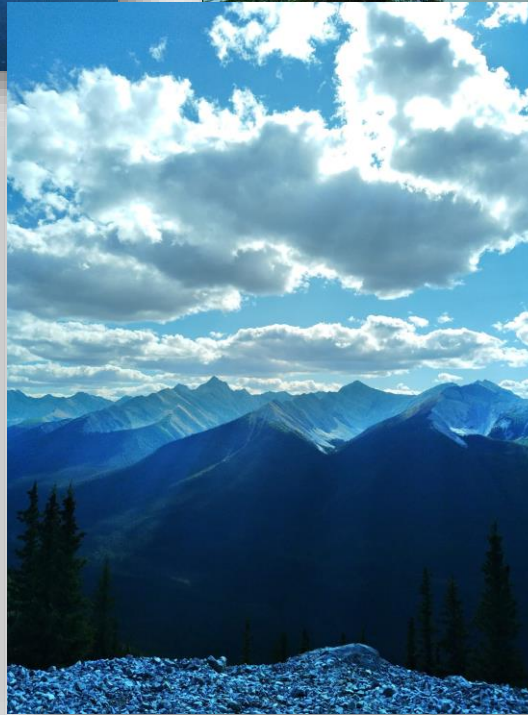




CERN Cryomodule Contributions – SPS RFD & AI.

S. Barriere, T. Capelli, L. Dassa, J. Debeux, Marco Garlaschè
on behalf of WP4 Cryomodule Team



Summary

- An update on cryomodule collaboration activities CERN-side
- Some feedback & comments for the ongoing & upcoming activities

... complementary to the other CERN cryomodule presentations

Series cryomodule design

Teddy Capelli

Cavity/cryomodule alignment

Vivien Rude

Vacuum aspects & procurement status

Vincent Baglin et al.

Cryogenics

Krzysztof Brodzinski

... and more on components (Eric, Nuria, Simon, Katarzyna,...)

Reminder on WP4 CM Planning

WP4 - Schedule in work for CSR23

SPS @ LSFC

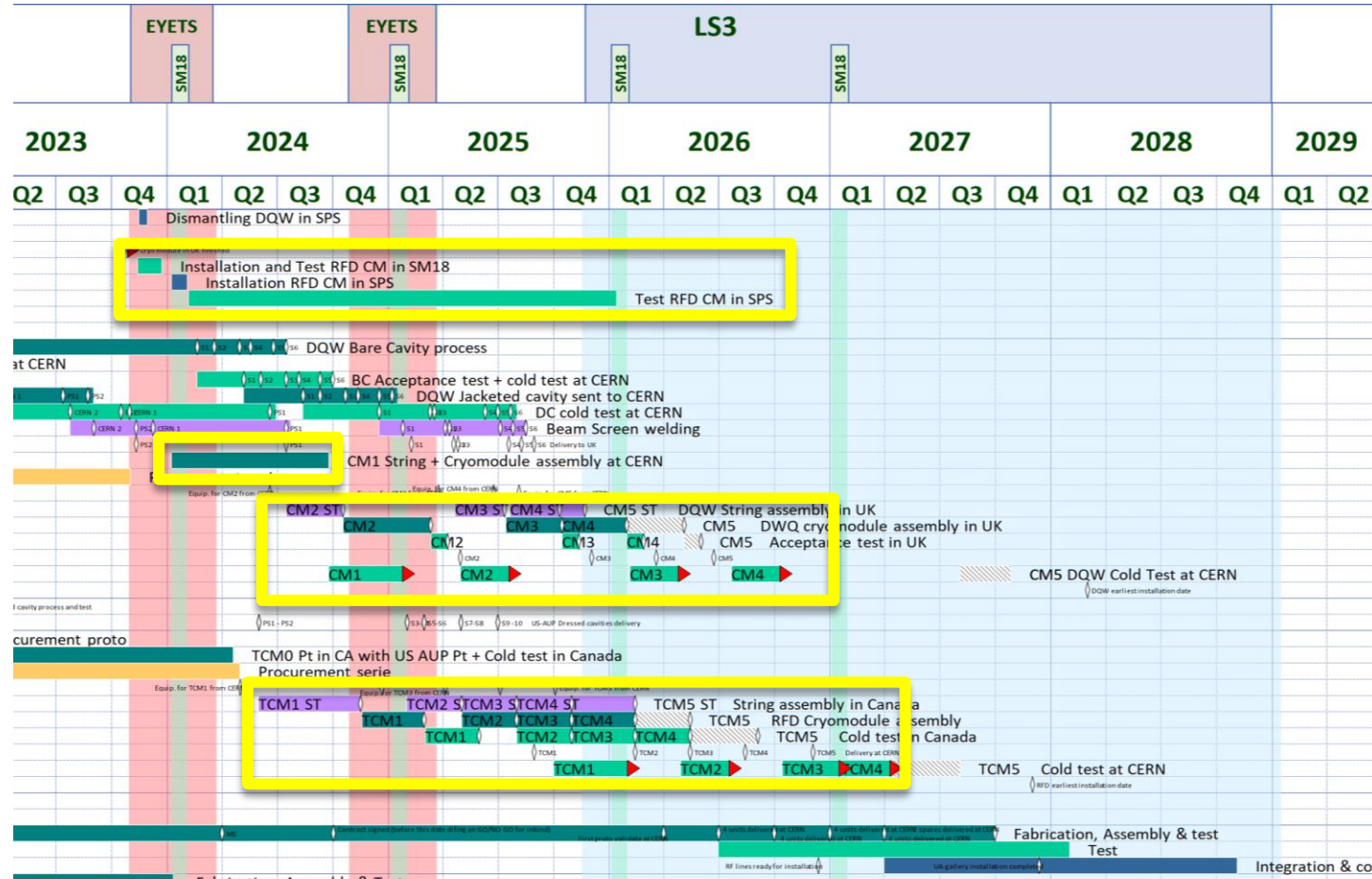
Cryomodule (4CC, 2CM)

DQW

RFD

LHC @ IR1 & 5

HPRF



- Three types of CERN 'Contributions':
- **Hardware** (Part Exchange) and related handling/assembly procedures
 - **Info** : Design (components, CM), CERN **Specifications**
 - **Specific Technical Support**

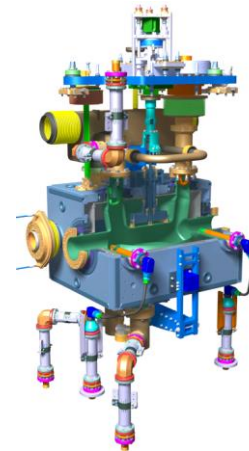
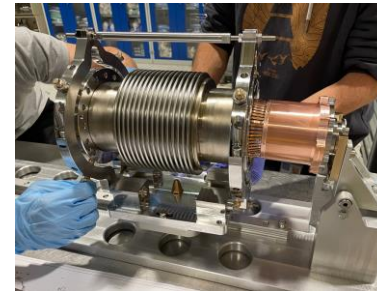
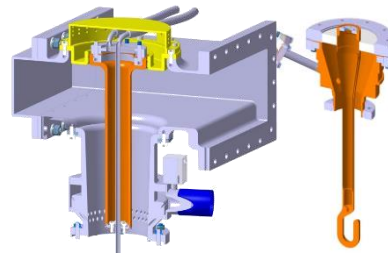
CERN Contribution within Collaboration: Hardware

For more info on equipment. See specific talks (N. Valverde, E. Montesinos, S. Barriere, V. Baglin, ...)

Components for **RFD SPS UK cryomodule**. All delivered.

- **Components for cleanroom string assembly**

- Dressed Cavity with HOMC
- FPC
- PIMS / RF fingers
- Vacuum chambers & valves



- **Components for cryostating**

- Tuner frames & actuation
- Thermal shield & cooling lines (fully qualified)



CERN Contr. : Hardware – CERN DQW

*DQW CAVITY ASSEMBLY

Tuner Actuation
LHCACFTU0215

EDD: Q1-2024

FPC
LHCACFMC

Hardware for [2x]
subassemblies :

Dressed Cavity + Auxiliary

HOM filter
LHCACFHC

Beam screen
LHCVSSCA0031

DQW Cavity
LHCACFCA

EDD: Q1-2024

Helium Tank
LHCACFHT

Cold magnetic shield
LHCACFCMO

HOM filter
LHCACFHC0

	design being finalized
	fab. ongoing @ CERN [*]
	ready

[*] EDD = hardware production finalized. Not Tested

HOMs coaxial line
LHCACFRLO

Pick up coaxial line
LHCACFRLO

EDD: Q1-2024

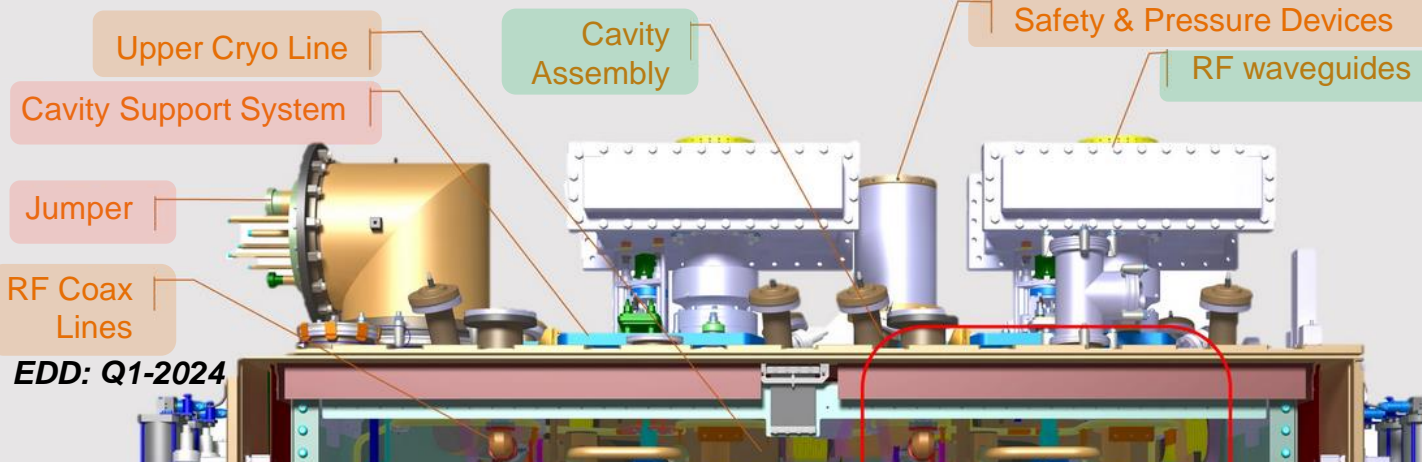
Pick Up Antenna
LHCACFHC0

Tuner Frame
LHCACFTU

EDD: Q1-2024

CERN Contr. : Hardware – CERN DQW CM1

EDD: Q1-2024



EDD: Q2-2024

	design being finalized
	fab. ongoing @ CERN
	ready
	Fab. outsourced

EDD: Q1-2024

Cryostat assembly : critical & large cryomodule components launched and on track for activities in Q1/Q2-2024

EDD: Q1-2024

4-20K cooling line

Vacuum Vessel

EDD: Q1-2024

Gate Valves

PIMS (CW Transitions)

Thermal Screen

MLI

EDD: Q1-2024

EDD: Q1-2024

Magn. Shield

EDD: Q1-2024

RF Coax Lines

EDD: Q1-2024 Lower Cryo Lines

FSI heads

EDD: Q2-2024

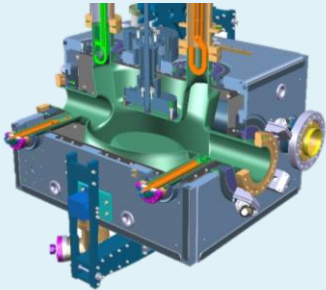
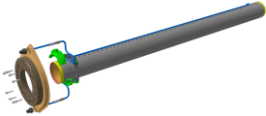
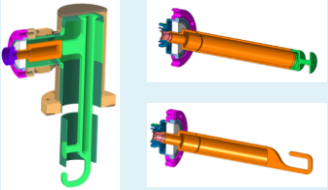
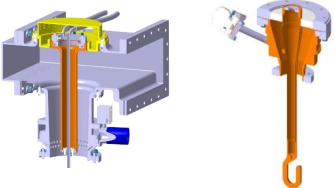

Jacks

CERN Contr. : Hardware - RFD & DQW Series

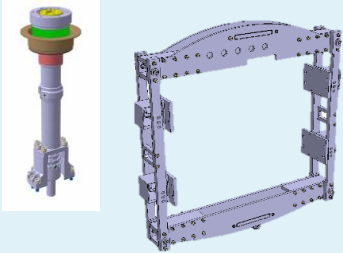
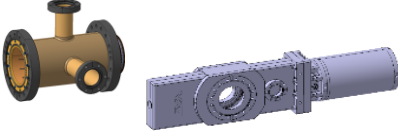

Ref. Part Exchange UK-CERN Ph2 : EDMS 2514308 + Addendum 2757659

Ref. Part Exchange CAN-CERN : EDMS 2508819

Blue = in line with Planning (WP4 MasterPlan & Collabs)

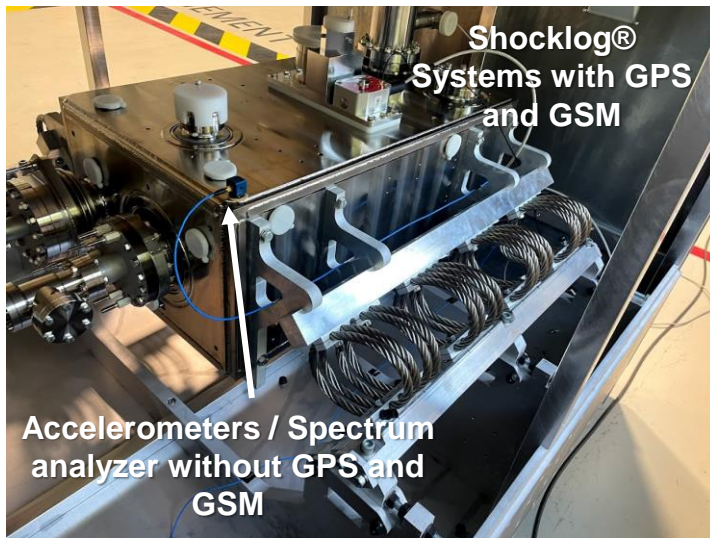
Component		Status & Estimated Delivery Date
<p>Jacketed Cavities</p> <p>(Bare Cavity + Cold Magnetic Shield + Helium Vessel)</p>		<p>DQW: See talk by Nuria Valverde RFD: See talk by AUP</p>
<p>Beam Screens</p>		<p>All Series: Ready</p>
<p>Full set of HOMs and HF-HOMs & Feedthroughs</p> <p>(High Order Modes Suppressors)</p>		<p>DQW: See talk by Simon Barrière RFD: See talk by Naeem Huque</p>
<p>FPC</p> <p>(Fundamental Power Coupler)</p>		<p>See talk by Simon Barrière</p>
<p>PIMS (Interconnections for string assembly)</p>		<p>2x DQW and 2x RFD: Sept-Oct 2023 (final welds ongoing) 3x DQW and 3x RFD: Q3-Q4 2024</p>

CERN Contr. : Hardware - RFD & DQW Series

Component		Status
Tuner Actuator & Frame		2x DQW: Q1-Q2 2024 3x DQW: Q1-2025
Vacuum Modules & Gate Valves		1x DQW and 1x RFD: Delivered to UK and Canada 4x DQW and 4x RFD: Ready @ CERN
RF Internal Coaxial Lines		2x DQW and 2x RFD: Q1-2024 3x DQW and 3x RFD: Q4-2024
Cryogenic Instrumentation		See talk by Krzysztof Brodzinski
Expansion joints for Cryogenic Lines* *added to CERN contribution		2x DQW and 2x RFD: Q2-2024 3x DQW and 3x RFD: Q4-2024

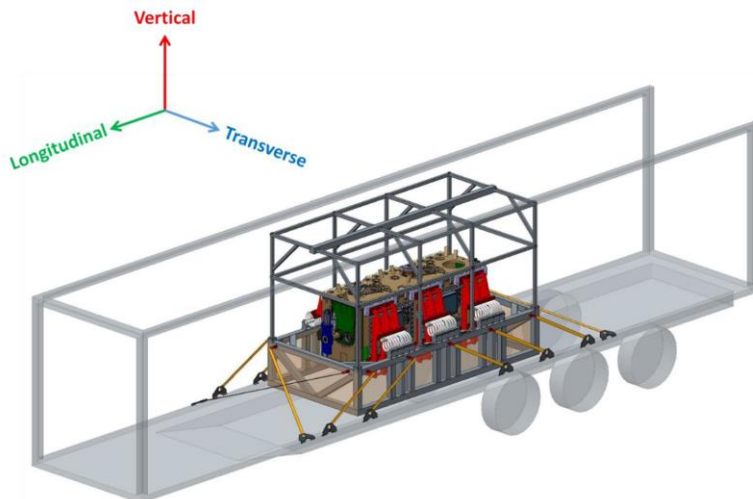
CERN Contr. : Transport

Courtesy K. Artoos, S. Barriere, C. Bertone, M. Guinchard, P. Minginette



2x RFD Dressed Cavities + sensitive auxiliaries (Sept. and Nov. 2021)

- Tool design inspired by UK Collaboration
- First transport with CERN internal transport service to facilitate potential troubleshooting
- Second transport with “standard” procedure (subcontractor)
- Mechanical instrumentation for GPS & live monitoring of shocks and vibrations:



RFD UK SPS CM (Oct. 2023)

- Tool design & fab by UK Collaboration
- Through CERN internal transport service
- Mechanical instrumentation for GPS & live monitoring of shocks and vibrations

To be discussed - Transport instrumentation/logging for:

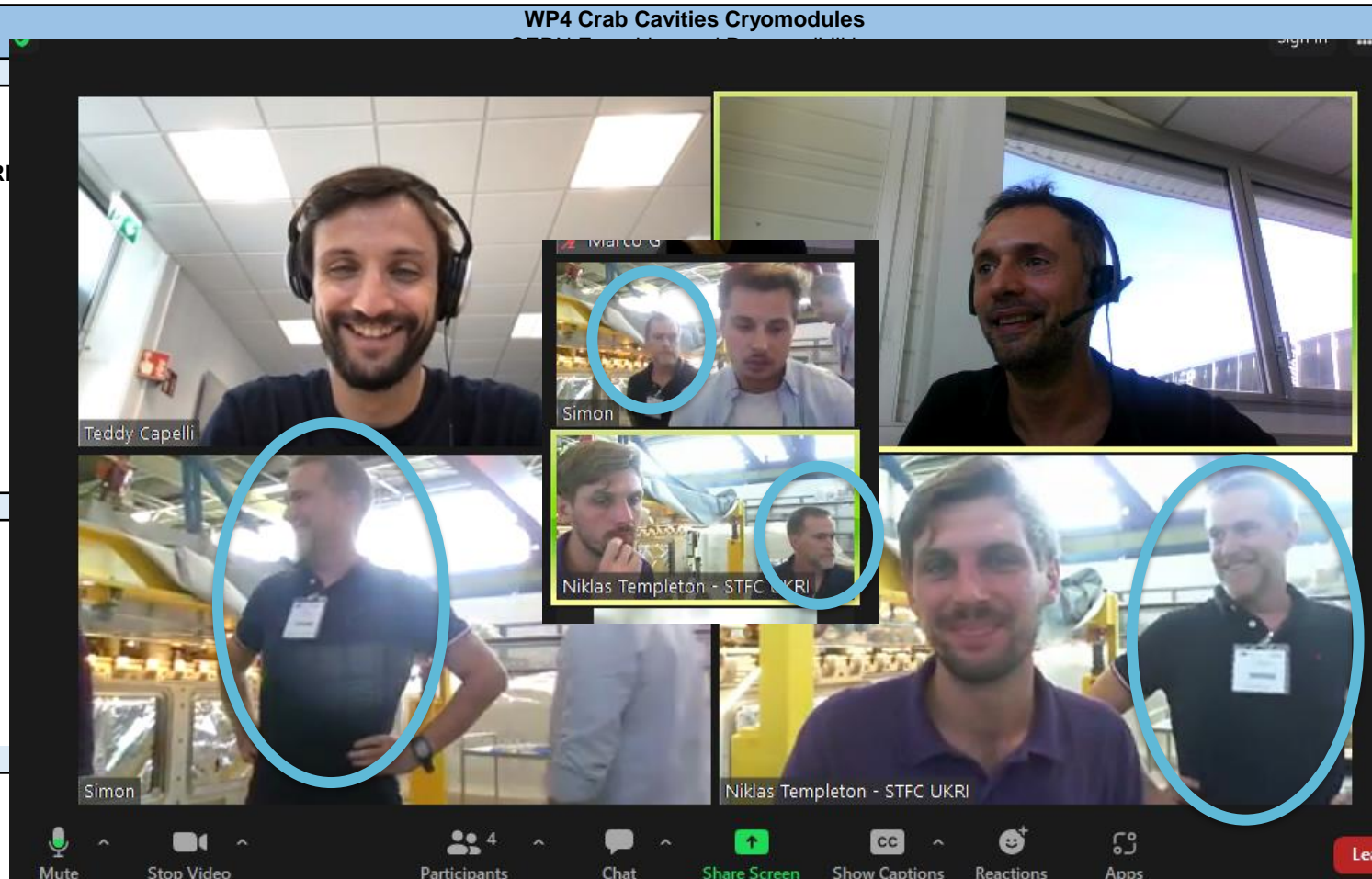
- RFD TCM1 (first flight)
- RFD & DQW Series

CERN Contr. : Tech. Support

Support on specific topics:

- Feedback on **activities** : QA, fabrication (welding, outsource)...
- **Tech. documentation** of Collab : Check **ass.y** and **test procedures**, **techSpecs** for prod
- Coaching & shadowing for **assembly of components under CERN responsibility**

CERN Reference people for topic / component / activity :



On CERN Specifications

Cryomodule & Components Specifications @ 2022 HL Week

CRYOMODULE

Scope	ID code	<u>Eng. Spec.</u> <u>[EDMS nr]</u>	<u>Guideline for compl. with</u> <u>CERN Saf. Req. [EDMS nr]</u>
Full Cryomodule, including beam screens and references to requirements for vacuum components (Sector valves, Plug-in modules)	ACFGA	<u>2043014 v.1.0</u>	2043016 v.0.1
Safety Request WP4 - Co CONTENT FOR THE DQW & RFD CRYOMODULE FOR LHC	ACFGA	<u>2514225 v.1.0</u>	
HL-LHC LHC CRAB CAVITIES: welded joints for cryomodule assembly	ACFGA	<u>2706475 v.1.0</u>	
Minimum Material Requirements for Austenitic Stainless Steel and Aluminium Alloys to be employed in non-critical applications	ACFGA	<u>2632333 v.1.0</u>	

COMPONENTS

Dressed cavities, HOMs couplers, Pick-up antennas, Cold magnetic shield	ACFDC, ACFHC, ACFPU, ACFCM	<u>1389669 v.2.6</u>	<u>2058183 v.1.0</u>
Cryogenic circuits	ACFQC	<u>2093032 v.1.0</u>	<u>2101920 v.1.0</u>
Thermal shield	ACFTS	<u>2101922 v.0.7</u>	<u>2101923 v.0.5</u>
MLI	ACFTS	<u>2144140 v.1.0</u>	-
Vacuum vessel	ACFVT	<u>2101924 v.1.1</u>	<u>2101925 v.1.0</u>
Warm Magnetic shield	ACFWM	<u>2101926 v.1.0</u>	-
Alignment monitoring system	ACFAM	-	-
Support and alignment system	ACFAH	-	-
Instrumentation (ONLY FOR RFD SPS)	ACFIS	<u>2450567 v.4 + CRNLSQLj0070 v.AA (PID)</u>	-
Fundamental Power Coupler	ACFMC	<u>2101934 v.1.0</u>	(? 2101936 v.0.1 ?)
RF internal lines	ACFRL	<u>2605345 v.1.0</u>	-
Tuning system	ACFTU	<u>2101938 v.0.1 / Mat. Cert. 2.2</u>	-
Safety protecting devices	ACFGA	<u>2101940 v.1.0</u>	<u>2101943 v.1.0</u>
Sector Valves (beam line)	VVG (TBC)	<u>§ 7.7 of 2043014 v.1.0</u>	-
Plug-in modules for Cold-Warm transition + Intercavity bellow	ACFVW + ACFVC (TBC)	<u>§ 7.7 of 2043014 v.1.0</u>	-
Beam screen	VSSC_	<u>§ 7.7 of 2043014 v.1.0</u>	-

STATUS

- **Released**
- **In Work**
- **To be issued if required (under discussion)**

Relevant for Safety

Cryomodule & Components Specifications @ Today

CRYOMODULE

Scope	ID code	<u>Eng. Spec.</u> <u>[EDMS nr]</u>	<u>Guideline for compl.</u> <u>with CERN Saf. Req.</u> <u>[EDMS nr]</u>
Full Cryomodule, including beam screens and references to requirements for vacuum components (Sector valves, Plug-in modules)	ACFGA	2043014 v.1.0	2043016 v.0.1
Safety Request WP4 - Co CONTENT FOR THE DQW & RFD CRYOMODULE FOR LHC	ACFGA	2514225 v.1.0	
HL-LHC LHC CRAB CAVITIES: welded joints for cryomodule assembly	ACFGA	2706475 v.1.2	
Minimum Material Requirements for Austenitic Stainless Steel and Aluminium Alloys to be employed in non-critical applications	ACFGA	2632333 v.1.0	

COMPONENTS

Dressed cavities, HOMs couplers, Pick-up antennas, Cold magnetic shield	ACFDC, ACFHC, ACFPU, ACFM	1389669 v.2.6	2058183 v.1.0
Cryogenic circuits	ACFQC	2093032 v.1.2	2101920 v.1.0
Thermal shield	ACFTS	2101922 v.1.0	2101923 v.0.6
He guard	-	2806004 v.1.2	TO BE PREPARED
MLI	ACFTS	2144140 v.1.2	-
Vacuum vessel	ACFVT	2101924 v.1.4	2101925 v.1.0
Warm Magnetic shield	ACFWM	2101926 v.1.2	-
Alignment monitoring system	ACFAM	-	-
Support and alignment system	ACFAH	-	-
Instrumentation (ONLY FOR RFD SPS)	ACFIS	2450567 v.4 + CRNLSQLj0070 v.AA (PID)	-
Fundamental Power Coupler	ACFMC	2101934 v.1.0	-
RF internal lines	ACFRL	2605345 v.1.0	-
Tuning system	ACFTU	2101938 v.0.1 / Mat. Cert. 2.2	-
Safety protecting devices	ACFGA	2101940 v.1.0	2101943 v.1.0
Sector Valves (beam line)	VVG (TBC)	§ 7.7 of 2043014 v.1.0	-
Plug-in modules for Cold-Warm transition + Intercavity bellow	ACFVW + ACFVC (TBC)	§ 7.7 of 2043014 v.1.0	-
Beam screen	VSSC_	§ 7.7 of 2043014 v.1.0	-

STATUS

- Released
- Under approval
- In Work
- To be reviewed

Relevant for Safety

CERN Specs under Release...

More info on the updates here:

[Crab Cryomodule Technical Meeting STFC/CERN \(30 August 2023\) - Indico](#)

[Crab Cryomodule Technical Meeting TRIUMF/CERN \(31 August 2023\) - Indico](#)

... some of the common modifications :

Reduced redundancy

- Links to drawings removed / drawings will refer to specs (and not the opposite)
- No 'list of changes' available: please take the time to review it for the series production

Clearer references

- List of relevant ISO GPS standards for manufacturing drawings
- List of acronyms added in few specs
- Updated Lists : required documentation, applicable rules and standards references

Updated Requirements for easing Qualifications and Inspections/Checks

- VT & Leak Check inspector
- Homogenization of cleaning requirements

General Comments & Lessons Learnt

On Specifications, QA

Attention to:

- compliancy with CERN **Safety Rules and Normative**. Implicit within CERN Eng. Spec.
- Collaborations are responsible to **abide to these**
- mismatch between **CERN Spec requirements & Drawings VS. translations by collabs** (read ISO vs. ASME). → DevReqs, PMAs, ...sharing of translations for feedback

Compliancy to Requirements also extend to assembly procedures

Collaborating entity is responsible. But CERN is there to provide direct feedback, previous experience, greenlight... (just foresee enough time for it)

Derogations :

- **DevReqs must be favored** (upstream)
- **NCRs** are reserved for unexpected **issues during fabrication**
- **NCRs are risky** (not accepted) and **lengthy** (during series, we may need to go up CERN and HL management until GLs, equipment owners, WP leaders,...)



On Specifications, QA

CAUTION: strong difference on ability to derogate, between RFD SPS [and TCM0] <> LHC series (e.g. NCR on Top Cryo Line support materials)

Pay special attention to **the (un)usual suspects (difficult derogation):**

- Pressure equipment (thermal shield & connections, cryo lines, dressed cavity)
- Material: 316LN (1.4429), % Cobalt, ferritic content and magnetism (as important as pressure)
- Overall normative requirements, especially on welds and NDTs

Some **existing useful “derogations”:**

- % Cobalt (EDMS 2514225)
- material requirements for less critical equipment (EDMS 2632333)
- on NDT qualif. for leak at Suppliers
- degreasing of equipment at supplier (provided done on equipment prior to assembly, and no retention areas)

For Series **components**

- anticipate issues @ enquiry stage : via **sharing and translating Tech Spec and QA requirements to suppliers**
- prior to fabrication kick-off : **acceptance of critical data**, (mat certificates, weld configs, qualifications)



On Specifications, QA, Series Production

For series **components & CM assembly**

- **Watch out in bulking series prod with 'prototypes'** (UK RFD, CAN TCM0)
- **MIP must be agreed** prior to launching specific production activities
- Attention to retain **hold points** as defined in CERN specs
- EDMS and MTF timely updated

Traceability of **incremental nonconformities** (e.g. total mass with OutOfSpec %Co)

Long lead items and raw material

- E.g. RFD-SPS: CERN has provided some raw material. (Minor-in-volume but critical-in lead-time. Mostly stainless steel 316LN for cryogenics lines)
- For series: procurement to be anticipated by collaborations

Long lead activities

Time needed for **qualifications/testing/preparation activities** must not be underestimated. Examples:

- time for production of assy procedures
- weld(er) qualification for cryo, following European normative



On Common CM Project Management

Cross-feeding and coworking is good

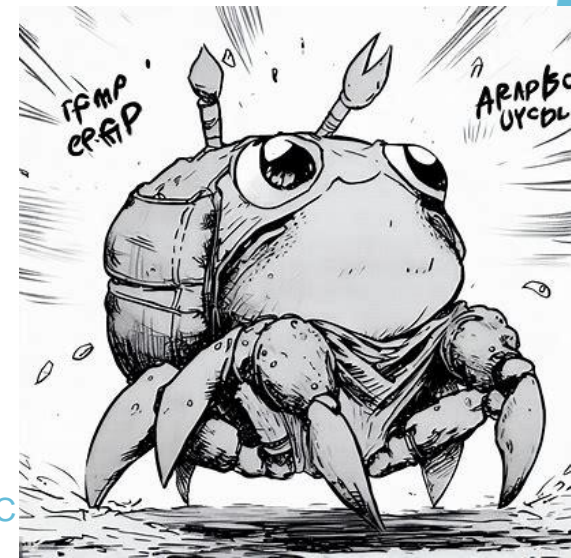
- Hardware & Information :currently beyond initial part exchange with UK and it has been vital.

Need to have a **shared planning** for equipment (lower level than CM). Shall avoid mismatch between:

- CERN info/hardware readiness <> Collaboration planning
- agreed info/hold points are paramount
- shared activities & visits

Need to:

- Minimize **impact of logistics**
- Streamline passage of **responsibility for equipment** (acceptance, corresponding MTF)



CERN Expectations for Series...

.. in the coming few months

Collabs Production Planning shared with CERN and in line with Master Plan (plus margin for critical equipment)

Strategy for series procurement of equipment fully defined:

- **Detailed “Who procures what”** (bellows, material, .. leak checks, controls)
- Eventual **Collab. Specs for production**: ready and checked with CERN
- Critical components: **initial QA** available
- **Anticipation** of all that experience has shown critical (**qualifications, material certificates**)
- **Free-issued critical material: secured**
- Avoid companies w/o clear reputation in Accelerator production. CERN can provide list of suppliers

Manpower and ref. persons on specific activities defined:

- QA/QC follow up (handling/updating info on EDMS/MTF)
- Welding engineer
- Assembly and welding technicians (**Qualifications!**)



Thanks!

Side technical discussions during this week. Please check and raise interest :

[Crab Cryomodule Technical Meetings TRIUMF/STFC/CERN @ HL-Week 2023 \(25 September 2023\) · Indico](#)