



# **CERN Design release milestone**

## **RFD cryomodule for LHC**

Teddy Capelli on behalf of CERN WP4 Team

19<sup>th</sup> February 2025

# Agenda

## **Introduction –10min**

Brief overview of the milestone's purpose and objectives

Collaboration with TRIUMF and CERN contribution

Master Planning

## **RFD Cryomodule engineering Overview –20min + 10min Q/A**

-Introduction to the RFD cryomodule

-Overview of the overall assembly sequence

-Status update on drawings and calculation

## **Close out & open discussions**

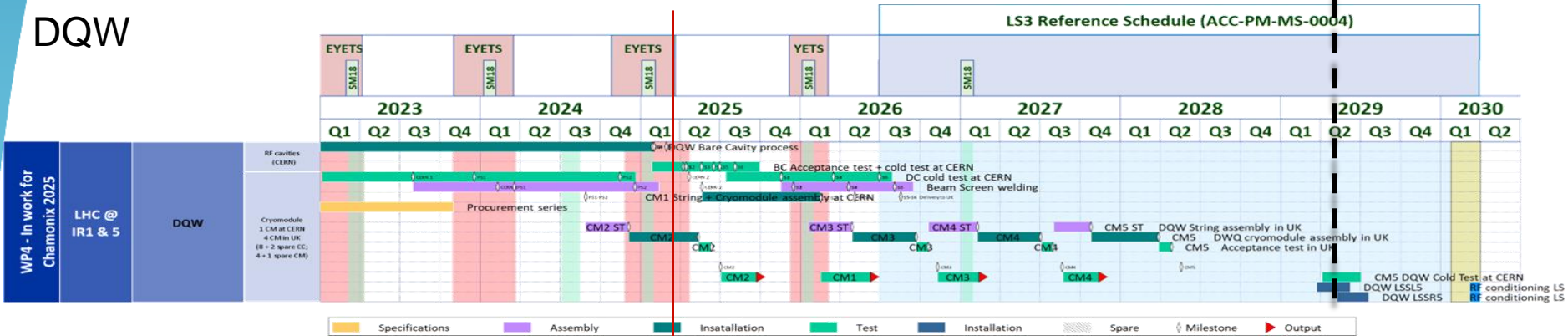
# Purpose of this meeting

- Provide a formal design release milestone to Triumf
- Give a reminder to CERN stakeholders about the design, status of drawing packages & implications of any changes
- Give an overview about the collaboration with Triumf
- Gather and address any comments about design

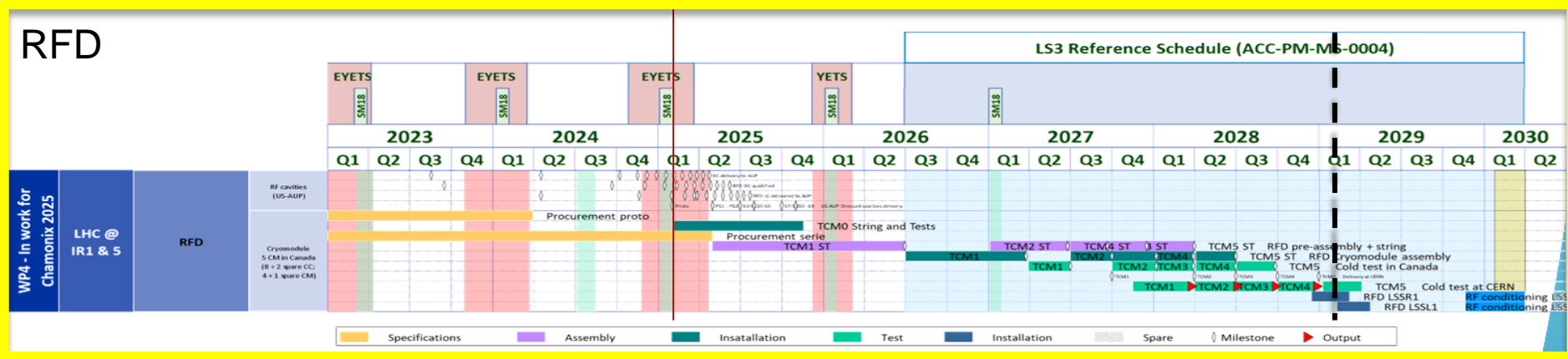
# WP4 Master Plan - RFD CM for information only

Latest installation

DQW



RFD



# CERN Contribution 1/2: Tech. Support

- Provide technical specifications for the design, manufacturing and testing of main components (see spare slide for the full list – Courtesy L.DASSA)
- Tech. Support on specific topics during CM manufacturing:
  - Feedback on activities : QA, fabrication (welding, outsource)...
  - Tech. documentation of Collab : Check ass.y and test procedures, techSpecs for prod
- CERN specialists visits on site :
  - Assembly intermediate checks/tests
  - Coaching & shadowing for assembly of components under CERN responsibility

Task Name	Start	Finish	Resource Names
Load the trolley with remaining components (cavities, and gro	15 Oct '24	14 Nov '24	Riggers
Alignment of components on the trolley	22 Oct '24	21 Nov '24	Metrology
Leak test of end groups	06 Dec '24	17 Dec '24	Vacuum
Beamline leak test	08 Jan '25	09 Jan '25	Vacuum
Install FPCs	12 Feb '25	17 Feb '25	CERN RF
Cavity lines leak and RF checks	17 Feb '25	26 Feb '25	Vacuum, RF
Fiducialization of top plate	10 Apr '25	11 Apr '25	Metrology
Fiducialization of lower OVC	30 Jan '25	03 Feb '25	Metrology
Alignment of FPC plate	03 Mar '25	06 Mar '25	Metrology
Welding of FPC plate	06 Mar '25	10 Mar '25	Welding
Installation of Mechanical Instrum on FPC pipes	10 Mar '25	10 Mar '25	Lab.
Welding of 2K filling line	12 Mar '25	12 Mar '25	Welding
Position & weld biphasic line	13 Mar '25	13 Mar '25	Welding
Weld 4-20k outline line	13 Mar '25	13 Mar '25	Welding
Weld H-HOM cooling lines	13 Mar '25	13 Mar '25	Welding
Leak test cryo welds	24 Mar '25	24 Mar '25	Vacuum
Assemble tuner frame	25 Mar '25	24 Mar '25	CERN Tuner
Install Cryo Instr. I/G	31 Mar '25	31 Mar '25	Cryo
Install Tuner double pipe with braids	07 Apr '25	09 Apr '25	CERN Tuner
Install OVC Top Plate FSI heads	09 Apr '25	10 Apr '25	CERN Metrology
Install Lower OVC FSI heads	09 Apr '25	10 Apr '25	CERN Metrology
Alignment of top plate WRT strip	22 Apr '25	23 Apr '25	CERN Metrology
Install cryogenic instrument	10 Apr '25	11 Apr '25	Cryo
Connect V-HOMs and H-HOMs to cavity and instal	11 Apr '25	22 Apr '25	CERN RF
Lower top plate onto top plate (done during Step 5)	22 Apr '25	22 Apr '25	CERN Metrology
Weld cavity supports	23 Apr '25	24 Apr '25	Welding
Leak check (cryogenic)	24 Apr '25	25 Apr '25	Vacuum
Weld top plate Helium levels ports, and cryogeni	25 Apr '25	25 Apr '25	Welding
Inspect cavity leak check	25 Apr '25	06 May '25	Vacuum
Install cavity supports	06 May '25	07 May '25	CERN MME
Install FSI heads on cavity flanges	06 May '25	07 May '25	CERN Metrology
Connect coaxial lines to top plate	06 May '25	06 May '25	CERN RF
Load transfer from trolley to top plate	09 May '25	13 May '25	Riggers
Position and weld the 4-20K heater and inter beam screen lin	14 May '25	16 May '25	Welding

To be provided by Triumf

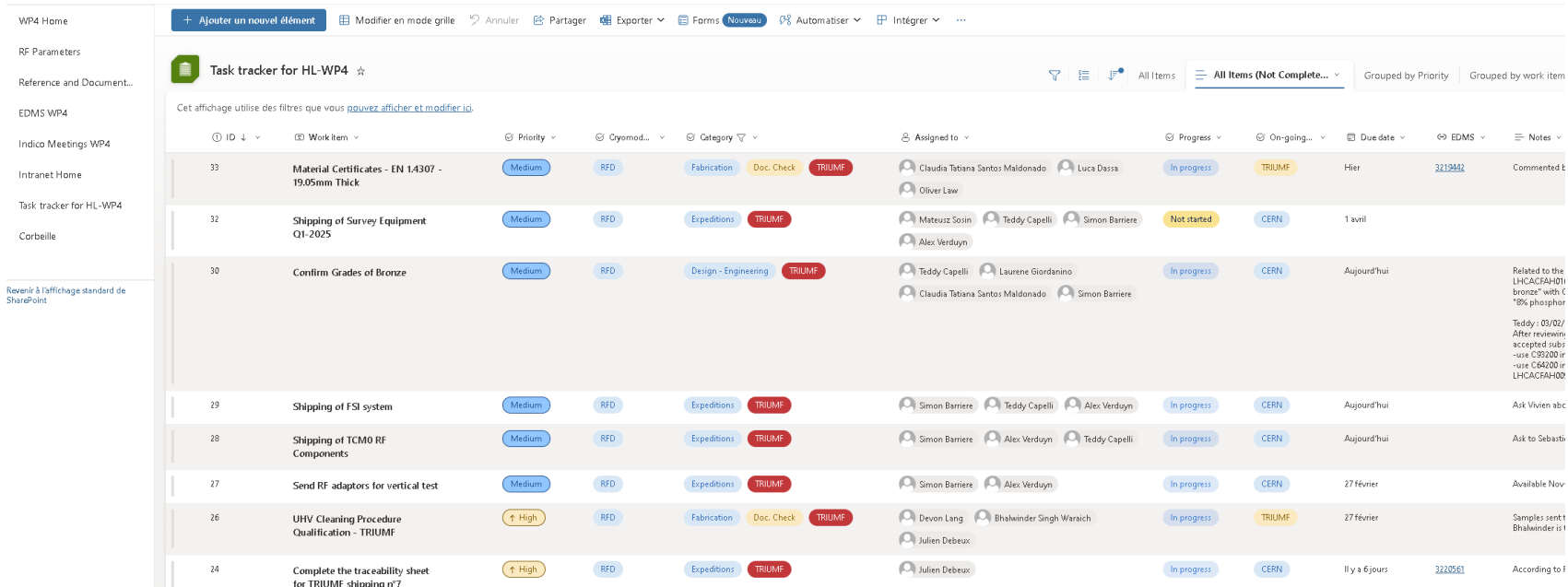
# (Task tracker for WP4)

CERN internal tool stored on WP4 sharepoint ([Link here](#))

Follow up of open actions (NCR, Dev. Req., Document review ... etc)

 WP4 Crab Cavities & RF System

Courtesy I.BEJAR ALONSO, J.DEBEUX, M.BENAHMED



ID	Work item	Priority	Category	Assigned to	Progress	Due date	Notes
33	Material Certificates - EN 1.4307 - 19.05mm Thick	Medium	Fabrication	Claudia Tatiana Santos Maldonado, Luca Dassa, Oliver Law	In progress	Hier	321942
32	Shipping of Survey Equipment Q1-2025	Medium	Expéditions	Mateusz Sosin, Teddy Capelli, Simon Barriere, Alex Verduyn	Not started	1 avril	
30	Confirm Grades of Bronze	Medium	Design - Engineering	Teddy Capelli, Laurene Giordanino, Claudia Tatiana Santos Maldonado, Simon Barriere	In progress	Aujourd'hui	Related to the LHCACFAH01 bronze" with C 8% phosphor Teddy: 03/02/ After reviewing accepted subs -use C09200 in -use C04200 in LHCACFAH00
29	Shipping of FSI system	Medium	Expéditions	Simon Barriere, Teddy Capelli, Alex Verduyn	In progress	Aujourd'hui	Ask Vivien abc
28	Shipping of TCMO RF Components	Medium	Expéditions	Simon Barriere, Alex Verduyn, Teddy Capelli	In progress	Aujourd'hui	Ask to Sebastien
27	Send RF adaptors for vertical test	Medium	Expéditions	Simon Barriere, Alex Verduyn	In progress	27 février	Available Nov
26	UHV Cleaning Procedure Qualification - TRIUMF	High	Fabrication	Devon Lang, Bhawinder Singh Waraich, Julien Debeux	In progress	27 février	Samples sent to Bhawinder is t
24	Complete the traceability sheet for TRIUMF shipping n°7	High	Expéditions	Julien Debeux	In progress	Il y a 6 jours	3220501 According to f

Today ~70 tasks opened – ONLY 1 Cryomodule under assembly at STFC  
Many more tasks to come !

# Interfaces CERN/Triumf

*CERN Reference people for topic / component / activity:*

WP4 Crab Cavities Cryomodules CERN Front Line and Responsibilities	
Project ACTIVITY	RESPONSIBLE
General	Teddy CAPELLI
Tracking of design changes , 'as built'	Laurene GIORDANINO
CERN Components Center (i.e. CERN Production Readiness, feedbacks for production,...) Tracking of assets. CERN Logistics & Shipping IN / OUT	Simon BARRIERE Simon BARRIERE, Alex VERDUYN
WP4 QA/QC Follow-up [+ Welding ] Conformity to HL Quality Assurance & Control (CERN Reference Entity) + DevReQs Specifications & Conformity thereof (ref. person for WP4 CERN)	Julien DEBEUX, Myriam BENAHEMED Hector GARCIA GAVELA Luca DASSA, Isabel BEJAR ALONSO
MTF steps approval, procedures, NCRs, DevReqs drafting, ...	EDMS distribution list: WP4_Cryomodule_UKCERN, WP4_Cryomodule_CANADACERN
Conformity to Specifications	EDMS distribution list: WP4_Cryomodule_UKCERN, WP4_Cryomodule_CANADACERN
Cryomodule ACTIVITY	CERN KEY PERSON
Overall Cryomodule Design , Assembly (& support thereof)	Teddy CAPELLI, Laurene GIORDANINO, Ghislain GIROD
Vacuum	Giuseppe BREGLIOZZI
Alignment	Vivien RUDE
Cryogenics	Laurent DELPRAT, Vanessa GAHIER
Materials	Claudia SANTOS MALDONADO
Mechanical instrumentation	Michael GUNCHARD
Transport Engineering & Design	Kurt ARTOOS
Clean Room	Nuria VALVERDE
RF testing + CM SM18 Activities	Rama CALAGA, Nuria VALVERDE
Component	
Couplers & RF	Nuria VALVERDE, Sebastien CALVO
Tuner	Kurt ARTOOS
Transport Equipment	Simon BARRIERE, Kurt ARTOOS
Jacketed Cavity	Nuria VALVERDE
PIMS & Vac Components	Giuseppe BREGLIOZZI



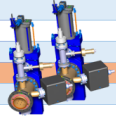

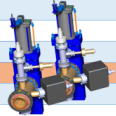
*Triumf Reference people for topic / component / activity :*  
*(to be updated by triumf)*

Bob Laxdal – project lead  
 Devon Lang – fabrication, assembly, alignment  
 Ben Matheson – Design  
 James Keir – fabrication, assembly, vacuum  
 Oliver Law – Engineering  
 Bhalwinder Waraich – clean assembly  
 Zhongyuan Yao – cavity and cryomodule testing

# CERN Contribution 2/2: Hardware

- Triumf to Manufacture components and assemble 4 RFD series cryomodules :
- Collaboration agreement on part exchange and responsibilities of production :

**Ref. Part Exchange UK-CAN : EDMS 2508819 + Amnd Add5 of P095**  
**Detailed bill of material with responsibilities and status : EDMS 3020997**

RFD LHC Assembly - BOM Step 1 to 12 - EDMS 3020997																	
Step 1 to 12 updated																	
ST number	Definition	CDD / SCEM / Supplier ref	Qty per CM	Spare ?	Material	Step of assembly	Cleaning inside	Cleaning outside surfaces	Special treatment	Hardware Production Responsibility	# HW responsibility CERN, which surface/treatment conditions @ delivery?	Picture	Comment	Included in original part exchange list?	COSET OR (Unit Lot)	Status TCM0	Status Series
ST1631733	LHC RFD cryomodule - ASSEMBLY Step 1	LHCACF_A0055	1			0											
ST1604537	LHC-RFD HE TANK + BEAM SCREEN ASSY	LHCACFD0013	2			0											
ST180364	BESPOKE UHV CP FIXED FLANGE BR2-95x5	LHCYSSCA0918	2			0	CL condition	CL condition		AUP??				N/A			
ST180302	CONICAL HALF CLAMP FX - BEAM SCREEN	LHCYSSCA0917	4			0	UHV clean	UHV clean		AUP??				N/A			
ST180440	LHC-RFD DRESSED CAVITY PARTIAL ASSEMBLY	LHCACFD0011	2			0	UHV clean	UHV clean		AUP??				N/A			
ST180756	BEAM SCREEN BELLOWS WITH FLANGE	LHCYSSCA0919	2			0	UHV clean	UHV clean		CERN	UHV clean			YES		Ready for assembly on cavity	Ready for assembly on cavity
ST1007365	BEAM SCREEN/FPE ASSEMBLY BEFORE FINAL WELD-BULK VERSION	LHCYSSCA0824	2			0	UHV clean	UHV clean	Carbon-Coating	CERN	UHV clean			YES		Ready for assembly on cavity	Production ongoing
ST1033786	GRFFE F 0422mm	LHCACFC0235	2			0	UHV clean	UHV clean		AUP??				N/A			
ST1033893	ELBOV 90 MACHINING - 03x2	LHCACFC0254	2			0	UHV clean	UHV clean		AUP??				N/A			
ST103201	ROUND TUBE 03034		2			0	UHV clean	UHV clean		AUP??				N/A			
ST180240	VENTED SK THD CAP SCREW M4x2 OKx4 NO CHC FORCE W/2 OKx4		12			0	UHV clean	UHV clean		AUP??				N/A			
ST1807229	SCHNORR S Washer - 7.4.3.0.5		12			0	UHV clean	UHV clean		AUP??				N/A			
ST095266	GRFFE F BULK CAVITY/FPE CRAB CAVITY DOV - SPS TEST	LHCACFC0053	2		EN14429 CERN ZDF EDMS 2607219838 Stainless Steel CERN FTMC2003010					AUP??				N/A			
ST095279	GRFFE F B3x15mm CRAB CAVITY DOV - SPS TEST	LHCACFC0064	2		Stainless Steel					AUP??				N/A			
ST1856274	VALVE PLATE	LHCACFY0044	1		Stainless Steel	1	CL condition	CL condition		TRIMM			Part of the DVC	N/A			
ST1412459	VARICH_ZB - Chamber 1	LHCVA__0202	1			1											
ST120684	RF Valve DN00CF(BR2) - Apert DN80	YAT_42238-XE74-ANN1	1		Stainless Steel	1	CL condition	CL condition		CERN	UHV clean			YES		Delivered	Delivered
ST124541	CRAB CAVITY - EXTREME VACUUM CHAMBER FOR INSTRUM - VCA0A0402	LHCYMACAA_T081	1			1	CL condition	CL condition		CERN	UHV clean			YES		Manufactured, preparation ongoing	Manufactured, preparation ongoing
ST123860	VYFM003 - ANGLE VALVE T-Shape DN80	YAT_54122-GE02-AR11	1		Stainless Steel	1	CL condition	CL condition		CERN	UHV clean			YES		Manufactured, preparation ongoing	Manufactured, preparation ongoing



# Conclusions

- Change in the design of the cryomodule or one of its sub-components impacts not only drawings but also :
  - Assembly procedures
  - Calculation/simulations
  - Technical specifications
  - Planning
  - Integration
- Every modification must be documented and validated by both CERN and Triumf -> Contact us
- Follow up cryomodule activities are of utmost importance, and we need everybody involved to review request from the collaboration



***Questions ?***

# Cryomodule & Components Specifications

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	<a href="#">2043014 v.2.0</a>	<a href="#">2043016 v1..0</a>
Safety Request WP4 - Co CONTENT FOR THE DQW & RFD CRYOMODULE FOR LHC	ACFGA	<a href="#">2514225 v.2.0</a>	
HL-LHC LHC CRAB CAVITIES: welded joints for cryomodule assembly	ACFGA	<a href="#">2706475 v.1.3</a>	
Minimum Material Requirements for Austenitic Stainless Steel and Aluminium Alloys to be employed in non-critical applications	ACFGA	<a href="#">2632333 v.1.0</a>	

## CRYOMODULE

Dressed cavities, HOMs couplers, Pick-up antennas, Cold magnetic shield	ACFDC,ACFHC, ACFPU, ACFM	<a href="#">1389669 v.2.6</a>	<a href="#">2058183 v.1.0</a>
Cryogenic circuits	ACFQC	<a href="#">2093032 v.1.4</a>	<a href="#">2101920 v.1.1</a>
Thermal shield	ACFTS	<a href="#">2101922 v.1.2</a>	<a href="#">2101923 v.1.0</a>
He guard	-	<a href="#">2806004 v.1.4</a>	
MLI	ACFTS	<a href="#">2144140 v.1.3</a>	-
Vacuum vessel	ACFVT	<a href="#">2101924 v.1.6</a>	<a href="#">2101925 v.1.1</a>
Warm Magnetic shield	ACFWM	<a href="#">2101926 v.1.4</a>	-
Alignment monitoring system	ACFAM	-	-
Support and alignment system	ACFAH	-	-
Instrumentation ( <b>ONLY FOR RFD SPS</b> )	ACFIS	<a href="#">2450567 v.4 + CRNLSQLj0070 v.AA (PID)</a>	-
Fundamental Power Coupler	ACFMC	<a href="#">2101934 v.1.0</a>	
RF internal lines	ACFRL	<a href="#">2605345 v.1.0</a>	-
Tuning system	ACFTU	<a href="#">2101938 v.0.1</a>	-
<b>Safety protecting devices</b>	ACFGA	<a href="#">2101940 v.1.0</a>	<a href="#">2101943 v.1.0</a>
Sector Valves (beam line)	VVG (TBC)	<a href="#">§ 7.7 of 2043014 v.1.0</a>	-
Plug-in modules for Cold-Warm transition + Intercavity bellow	ACFWW + ACFVC (TBC)	<a href="#">§ 7.7 of 2043014 v.1.0</a>	-
Beam screen	VSSC	<a href="#">§ 7.7 of 2043014 v.1.0</a>	-

## COMPONENTS

### STATUS

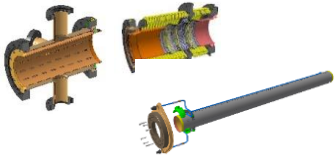
- Released
- In Work

Relevant for Safety

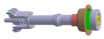
# Status of next shipments



- Cryogenic lines :
  - Upper lines – TCM0 sent – 1x series ready for march delivery **TBC**
  - Auxiliary lines – TCM0 sent – 1x series ready for march delivery **TBC**



- Beam vacuum equipment:
  - Instrumentation and pumps – TCM0 sent – Series under preparation for March delivery
  - Vacuum chambers and PIMS – TCM0 1x PIM under repair – Series under production
  - Beam screen for cavities – Production done – Shipping to be organised



- Tuner internal double pipe with bellows – 1x set for march delivery **TBC** – Series under production



- Cavity support blades with bellows – 1x set for march delivery **TBC** - Series under production



- Tuner external actuation - Design under review

- FSI :
  - Interferometer system – Ready to ship
  - Feedthroughs – to be sent at the last moment once calibrated
  - Target and support for cavities – 1x set Ready to ship

- RF adaptors – 2x sets calibration on-going for shipping week 7



- FPC – 1x FPC set in preparation on-going for shipping week 7 – Series under production
- FPC outer pipe – 1x FPC set in preparation on-going for shipping week 7 – Series under production