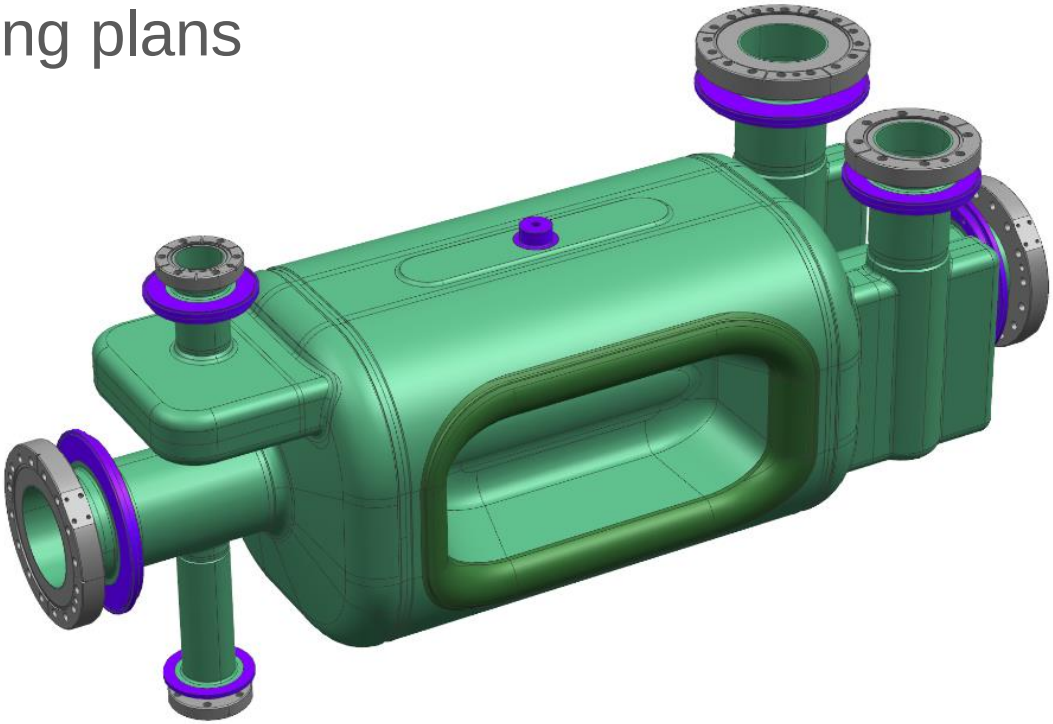
RFD Industrial Cavity Production

Manuele Narduzzi - FNAL

13th HL-LHC Collaboration Meeting – Sep 25th – 28th, 2023

Outline

- Series Niobium: status and issues
- Pre-series & Series RFD fabrication at ZRI
- He Tanks for Prototypes & Processing at ZRI
- Summary & Upcoming plans

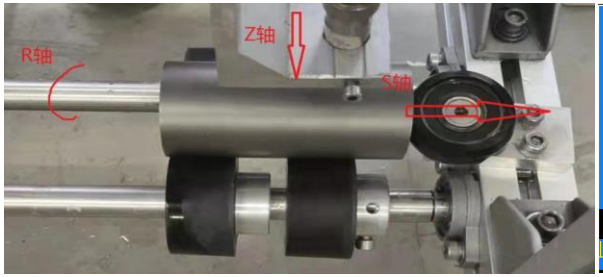


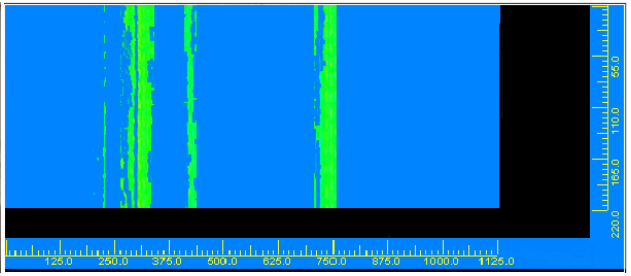
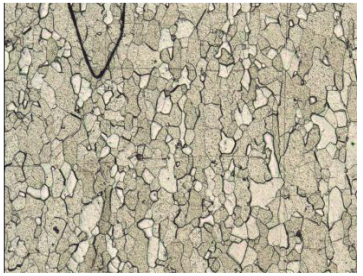
Series Niobium: status & issues (1)

- ✓ The material certificates and UT QCs are available on EDMS
  - ✓ Additional NDTs performed by AUP on Nb sheets

2244070 v.1.1	Material certificates and UT report, Order 657756 . Niobium RRR300. (Preseries production)	3	Released
2422456 v.1.1	Material certificates and UT report, Order 657756. Niobium RRR300. (Series production)	3	Released
2470058 v.1.4	Material certificates and UT report, Order 671157. Nb Rods & Plates, NbTi Rods & Disks. (Preseries production)	14	Released
2476239 v.1.6	Material certificates and UT report, Order 671490. Nb Tubes. (Pre-series production)	12	Released
2733735 v.1.6	Material certificates and UT report, Order 671157. Nb Rods & Plates, NbTi Rods & Discs. (Series production)	57	Released
2753455 v.2	Material certificates and UT reports, ZRI procurement of Niobium tubes and rods (Pre Series production, welding qualification)	10	Released
2655931 v.1	FNAL materials qualification for Niobium Sheet (Series production)	1	In Work
2733738 v.1.7	Material certificates and UT report, Order 671490. Nb Tubes. (Series production)	39	In Work

- ✓ The last batch of Nb tubes has been recently delivered to ZRI*
  - ❖ Delivery from Ningxia was delayed several months than expected
    - ❖ Postponed the Series Brazing Qualification!
  - ❖ CERN will carry out further NDTs on 2 of 8 unqualified tubes UTs



*ZRI is the acronym for "Zanon Research and Innovation"

Series Niobium: status & issues (2)

- Poles and WGs formed from series Nb shows non-repeatable results:
  - Some Poles showed less than desirable results even if formed from the same sheets used for acceptable components.
  - Waveguides require many coining steps to get close to the required shape accuracy, unlike pre-series ones.
  - AUP stock materials are enough for the manufacturing of 14 RFDs

Unacceptable Poles (left) and Acceptable Poles (middle) from the same Niobium sheet. Difficult stamping of Waveguides (right)

AUP Pre-series & Series Fabrication at ZRI

- ✓ Adopted CERN Eng. Spec. & Dwg for pre-series
- ✓ Approved Fab. Dwgs, MIP & QA/QC Procedures
- ✓ Approved Weld Test Plan
- ✓ Approved Welding book
- ▪ Finalizing Brazing Test Plan (Series only)
- ✓ Addressed all the reviews' recommendations

Documentation Prior to Manufacturing

- ✓ Adopted the HL-LHC quality system (MTF/EDMS)
- ✓ Enhanced QCs and VTS tests at FNAL & JLab

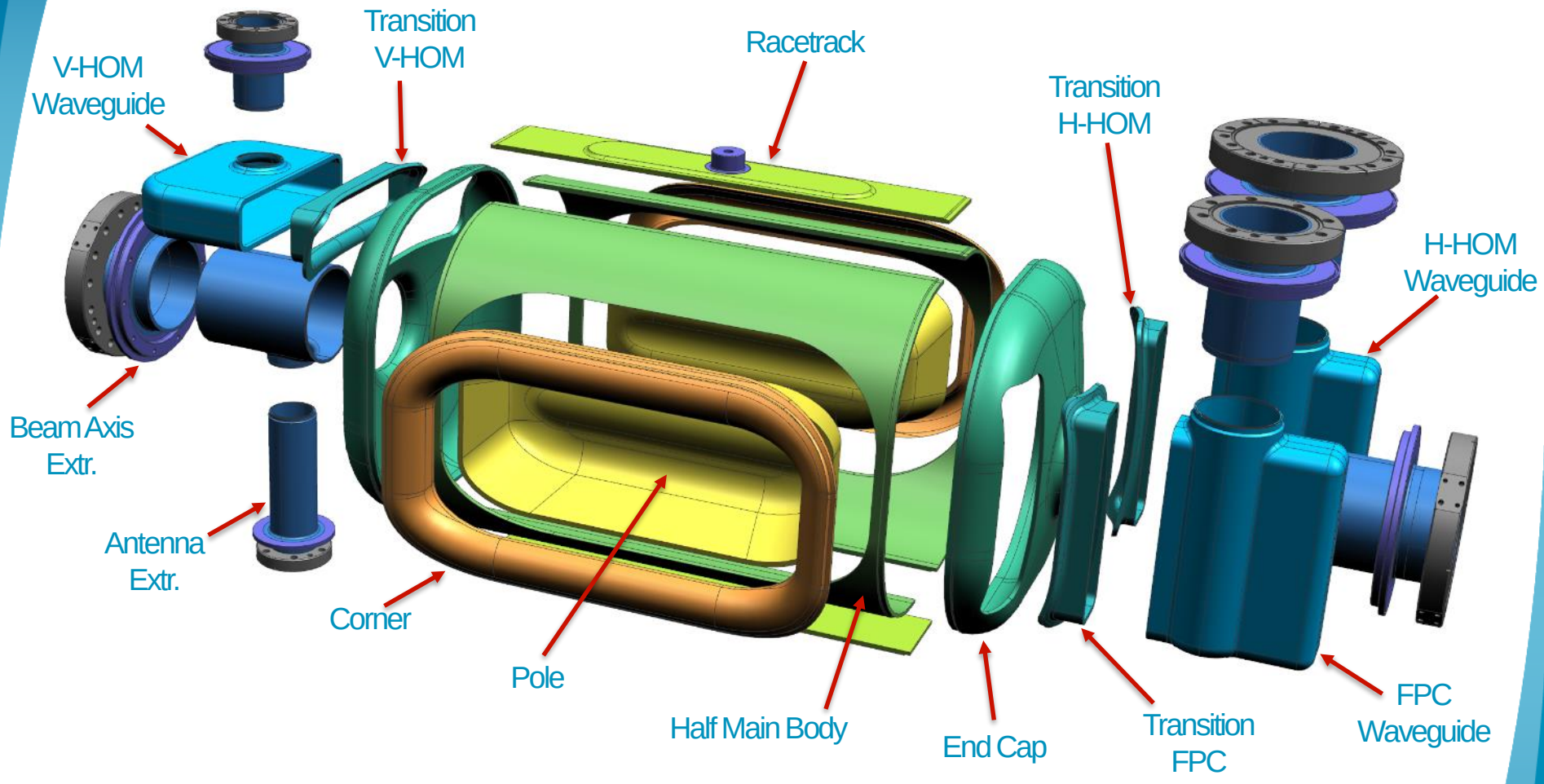
QA/QCs during production

98% of first 2x Pre-Series RFDs completed (delivery expected late 2023)

11% of 10x Series RFDs manufacturing has been completed

Documentation Prior To Manufacturing:

Pre-series & Series RFD Fabrication Strategy at ZRI

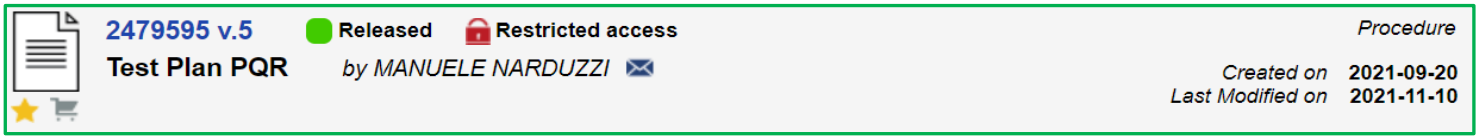


- ✓ Extremities tubes machined from Nb seamless pipes (no roll-forming)
- ✓ Single design for all the Transitions (machined from a block)
- ✓ Subcomponents interfaces and EBW joints handled as ZRI know-how
- ✓ Strategy validated with 2x Prototypes and 2x Pre-series bare cavities

Documentation Prior To Manufacturing:
Technical Documentation Status

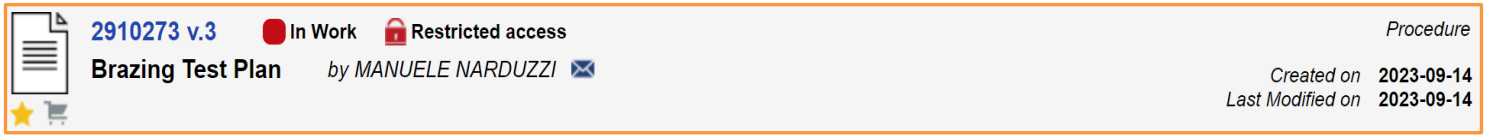
Fabrication drawings approved by CERN

Welding Test Plan PQR approved by CERN



Welding Book approved by CERN

Brazing Test Plan PQR (series only) to be approved



Documentation Prior To Manufacturing:
MIP and Procedures Status

QA & QC Procedures: 15 of 17 approved by CERN

Processing at ZRI

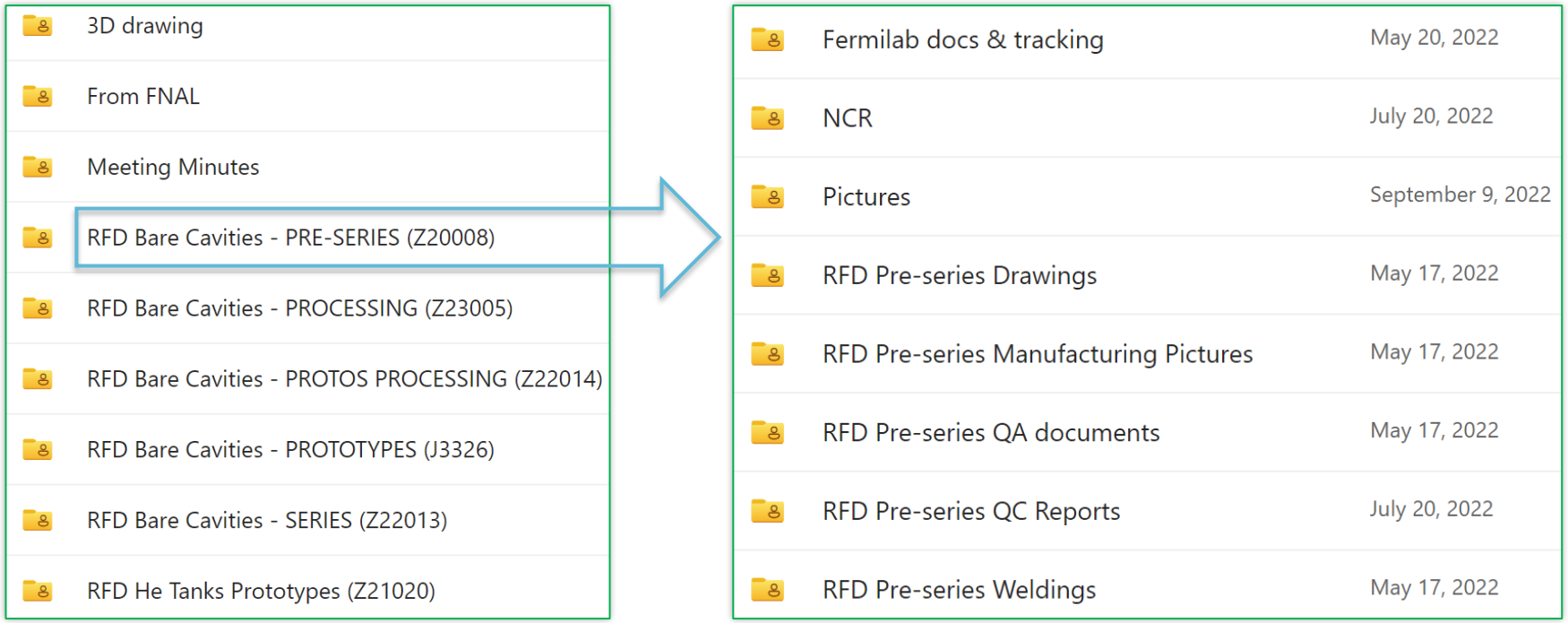
Being finalized

Being finalized

2901972 v.1.2	Assembly in cleanroom	1	Released	2023-07-27
2901976 v.2	Manufacturing Inspection Plan - Processing	1	Released	2023-07-27
2901971 v.2	BCP	1	Released	2023-07-27
2901969 v.1.1	High and Low Temperature Heat Treatment	1	Released	2023-07-27
2080731 v.1.1	HPR procedure	1	Released	2023-07-27
2683981 v.1	RFD Design process of adaptive rings and plates using metrol…	1	Released	2022-01-24
2080833 v.2	RF measurements & Trimming Procedure	1	Released	2021-10-13
2642947 v.1	Packing Procedure	1	In Work	2021-10-06
2630567 v.3	Grinding Procedure	1	Released	2021-09-30
2100569 v.2.2	Visual Testing	1	Released	2021-09-20
2080831 v.4	Leak Test procedure	1	Released	2021-09-20
2069497 v.3	Procedure for Radiographic Examination of Welds	1	Released	2021-09-20
2069496 v.1.2	Identification, Marking and Traceability Procedure	1	Released	2021-09-20
2069492 v.4	Cleaning and Etching Procedure	1	Released	2021-09-20
2080834 v.1.1	Dimensional Control Procedure	1	Released	2021-09-15
2069490 v.6	Manufacturing Inspection Plan - MIP	2	Released	2021-09-08
2080835 v.1.0	Pressure Test Procedure		In Work	2019-01-24

QA/QC During Fabrication:
Quality Approval Process between ZRI & AUP

- All QC reports are uploaded on FermiCloud by ZRI



- ZRI and AUP track QCRs approvals via signatures of completed production steps on MIP.
- The QCRs are checked and approved by FNAL (189 per Bare Cavity)
- AUP shares all the reports on EDMS / MTF

QA/QC During Fabrication:
Quality Approval Process between AUP & CERN (1)

“Approval Process MTF-EDMS for AUP RFD Crab Cavities” (EDMS 2896383)


2896383 v.1 Draft For Discussion Restricted access Note
Approval Process MTF-EDMS for AUP RFD Crab Cavities and Ancillaries
by NURIA VALVERDE ALONSO
Created on 2023-05-17
Last Modified on 2023-05-17

- CERN approves:
  - Fabrication drawings and Manufacturing Procedures: MIP, Welding & Brazing QA
  - NDT, welders and brazing operators' certificates
  - Raw material certificates and UT reports
- AUP uploads and releases all manufacturing reports to EDMS / MTF
- CERN reviews and releases:
  - Bare Cavities final frequency and metrology, UT thickness (after BCP) + Cold RF test
  - Dressed Cavities:
    - Pressure test + LT of He Tanks and 2nd Beam Pipe for Jacketed Cavities
    - Cold RF tests + Frequency at 2K+ for Dressed Cavities
- CERN reviews and closes all the NCRs

QA/QC During Fabrication:

Quality Approval Process between AUP & CERN (2)

"Handling, Sharing and approval of NCRs AUP-CERN" (EDMS 2384617)

2384617 v.1.0 Released Public access

Handling, sharing and approval of Nonconformities AUP-CERN *by H. Garcia Gavela*

Presentation / Publication

Created on **2021-08-10**
Last Modified on **2021-08-10**

- The NC Impact is assessed by AUP based on:
  - "AUP Quality Plan for vendors and FNAL Incoming Inspections NCs"
  - Technical, Schedule, Financial and Reputational impact
- Collaborations Impact Matrix used for assessment or escalate to CERN

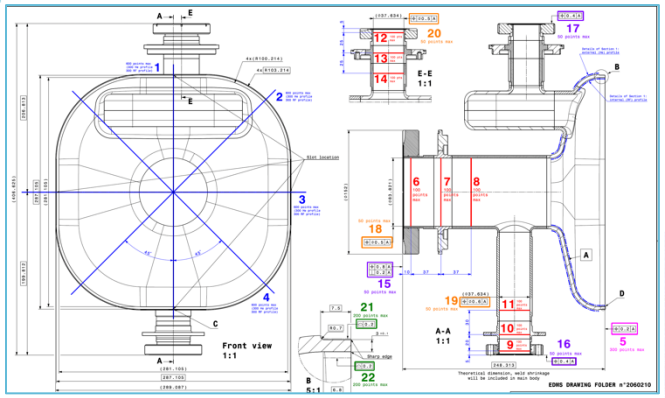
Impact assessment	Assessment scale	Financial loss	Reputation	Alignment with Business Objectives (WP Deliverables)	Who I shall inform in the project	When
Catastrophic / Extreme	5	Requiring resources outside the collaboration that can not be covered by the project	Large media (or scientific media) coverage - International coverage	Occurrence of the risk will significantly deter the achievement of all the objectives (ex, delay of the full project, not delivery of a component fully under the responsibility of the collaboration, ...)	PL, WPL, WPE	As soon as detected
Major	4	Requiring resources outside the collaboration that can be covered by the project	Host MS press coverage - Scientific media - Escalating community activism	Occurrence of the risk will significantly hamper the achievement of the of the objectives (ex, delay beyond the collaboration margin but not yet the WP margin, request of a permanent deviation permit for a component, engineering change request afecting the WP, ...)	PL, WPL, WPE	As soon as detected
Moderate	3	Requiring resources outside the collaboration but that can covered inside the WP	Local press coverage - Neighbourhood reputation (public, suppliers, etc.)	Occurrence will have some adverse effect on the achievement of the objectives (ex, delay eliminating al the margin, request of a deviation permit for a component, engineering change request, ...)	WPL, WPE	In the 3 days
Minor	2		No one has heard of the occurrence of risk outside CERN; Problem dealt with at CERN's management level.	Occurrence of the risk will have minimal impact on the achievement of the entity's business objectives (magnet, cold mass, cryoassembly)	WPE	During periodic feedback
Negligible	1		No one has heard of the occurrence of the risk outside he department who owned the risk; problem dealt at department management level	Occurrence of the risk will have very little or no impact on the achievement of the entity's business objectives (magnet, cold mass, cryoassembly)	WPE	During periodic feedback

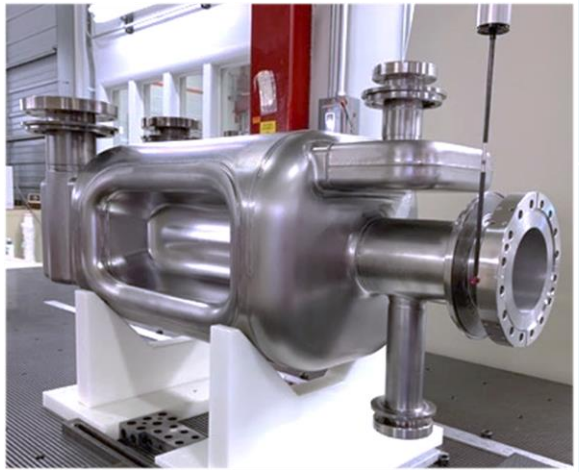
Non-critical NCs are managed internally
- Shared with CERN via MTF
- NCRs use vendor's templates
- Special attention to Welding

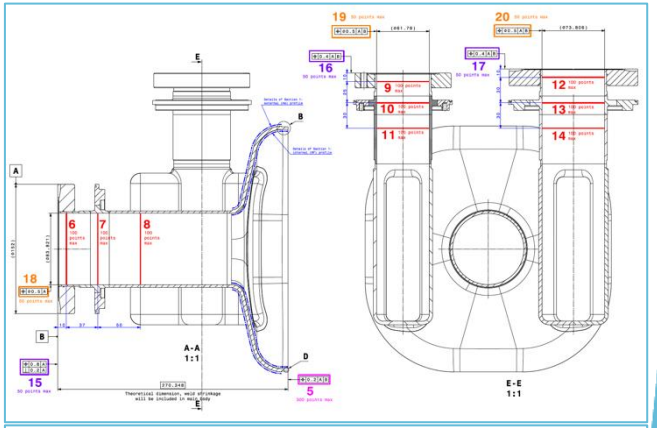
Critical NCs are managed as to HL-LHC NC Policy:
- Shared with CERN within days via MTF
- HL-LHC NC template is used
- 5 **W**s (**W**hat, **W**here, **W**hen, **W**ho, **W**hy)

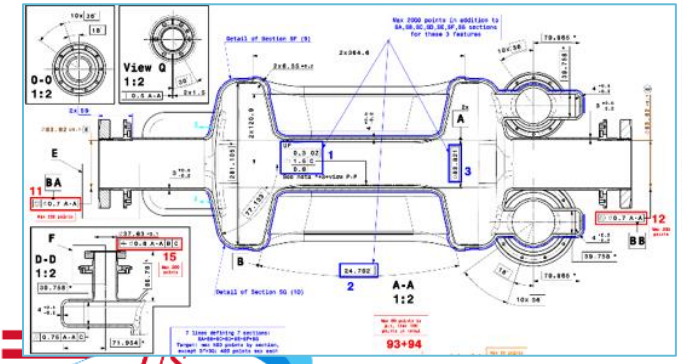
QA/QC During Fabrication:
Final Inspections of Bare Cavities at ZRI

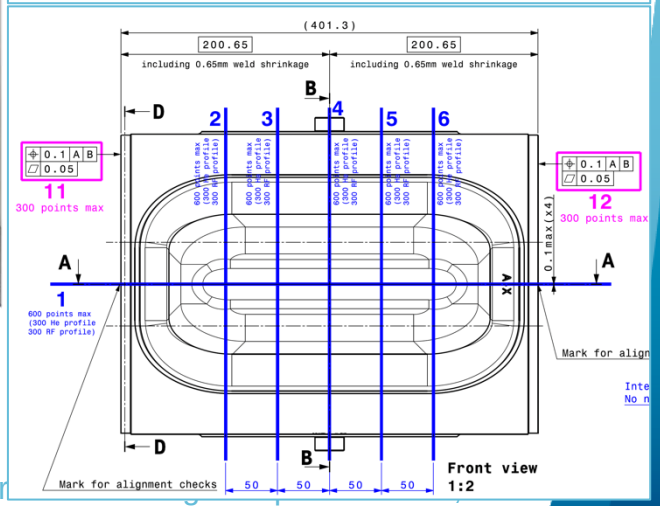
- VT (Visual Testing) + RT (Radiographic Testing) + RF (Frequency) check after EBW
- He LT (Leak Testing) → Final RF → Final CMM and Ultrasonic Thickness inspection
  - CMM as Inspection dwg LHCACFCA0565 and sub-assembly as (EDMS 2734588)
- VT of external surfaces + Traceability Report (of subcomponents)
- Approval of Manufacturing Dossier and Shipping to FNAL for VTS











Pre-series subcomponents before final EBW









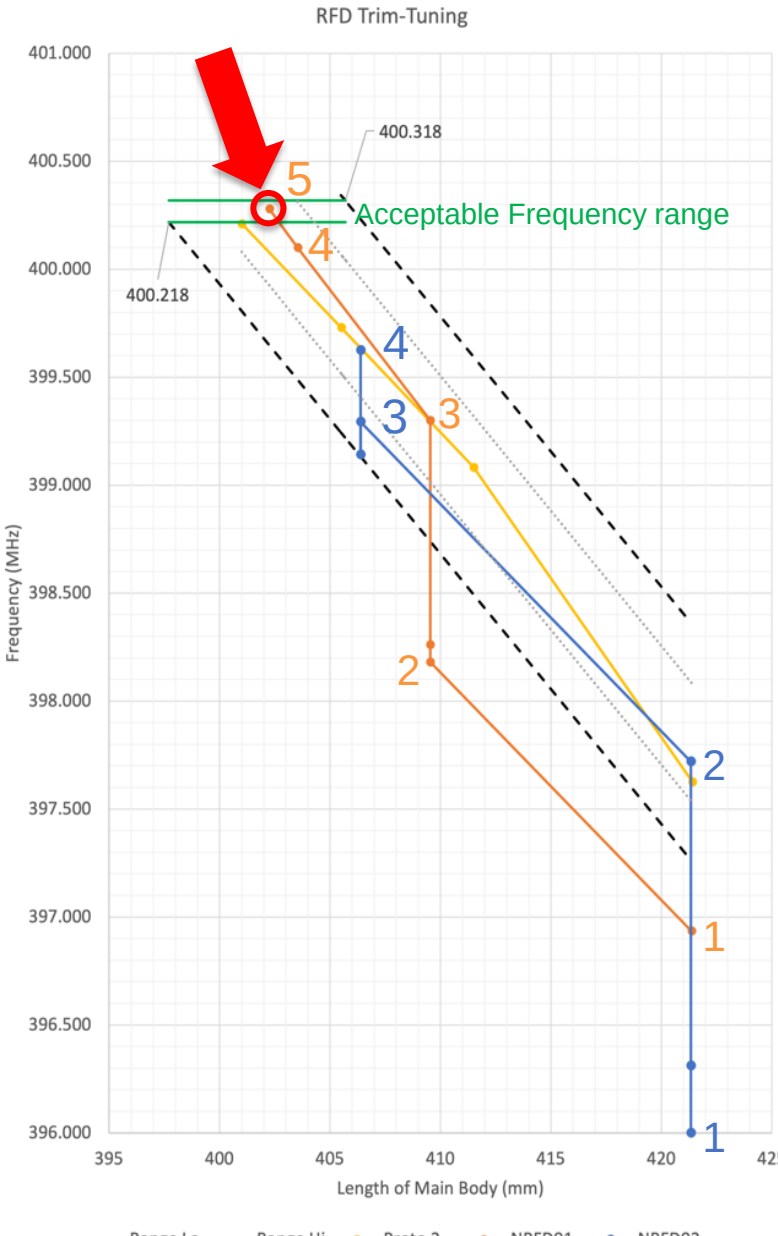
Pre-series RFDs: Trim Tuning Journey

NRFD01:

1. First RF check: frequency lower than expected caused by geometric non-idealities
2. First cut to check the *dF/dL*: lower than ideal
3. Two steps of reshaping for both Pole distance and Main Body interface with End Caps
4. Second cut: showed ideal *dF/dL*
5. Last cut provided results on target!

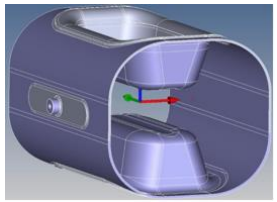
NRFD02:

1. First RF check: frequency lower than NRFD01
2. Poles and Bodies reshaping: RF on target
3. First cut: *dF/dL* lower than expected
4. Added a second two-step reshape to bring the cavity to the ideal frequency
5. Second cut: waiting for the results



Pre-series RFDs: Trim Tuning Journey

NRFD01 (Pre-series #1) Trim Tuning details



QCP		NRFD01		mode 1				mode 2				enviroment			Main Body	
QCP	step QCP	Date	Step	f (MHz)	Q_L	df (MHZ)	df/dL (MHz/mm)	f (MHz)	Q_L	df (MHz)	df/dL (MHz/mm)	T (°C)	P (hPa)	h (%)	L (mm)	dL (mm)
Z20008.QCP.001	--	6/8/23	prima della saldatura dei pins	396.775	6720			745.304	6864			22.7	990	55	421.40	
	--	6/12/23	dopo saldatura dei pins	397.043	6125	0.268		745.169	2885	-0.135		23.2	988	64		
	16.2	6/14/23	prima del taglio, dopo reshaping corpo	396.934	6176	-0.109		745.252	1464	0.083		23.1	986	52	421.37	-0.03
	16.6	6/22/23	dopo primo taglio	398.180	6226	1.246	-0.105	746.335	6923	1.083	-0.091	23.3	993	45	409.53	-11.84
		6/30/23	dopo primo taglio e light reshaping	398.261	6260	0.081		746.265	5000	-0.070		23.0	988	46		
		7/3/23	dopo light reshaping 2	398.435	6200	0.174		746.200	5000	-0.065		23.2	989	54		
		7/4/23	dopo ~~light~~ reshaping 3	400.300	6500	1.865		746.000	5000	-0.200		23.7	991	52		
		7/5/23	dopo chiusura cianfrini	399.300	5600	-1.000		746.130	2700	0.130		23.0	990	20	409.56	
	16.6	7/18/23	dopo secondo taglio	400.100	6443	0.800	-0.134	746.908	4833	0.778	-0.130	23.9	991	43	403.59	-5.97
	16.9	8/30/23	dopo terzo taglio	400.265	6000	0.165	-0.123	746.755	3500	-0.153	0.114	23.3	983	52	402.25	-1.34

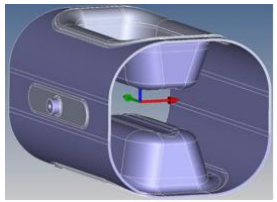
Disegno: Drawing:	3326.13.000.000 rev.0	QCP	Z20008.QCP.001
Identificazione: Identification:	Main Body	Cod. Part.: Item code:	MBW003

EVOLVING OF DIMENSIONS OF THE MAIN BODY

MBW003	*Nominal*	Before welding the PINs	After welding the PINs	After reshaping	After trimming	After reshaping [Pole ∅]	After reshaping [Pole Ø] 1	After reshaping [Pole Ø] 2	After reshaping [Pole Ø] 3	After chamfer reshaping	After trimming 2	Before EB welding
Step in drawing	--	2	3	3	3	3	3	3	3	3	3	4
QCP step	--	--	15.49	15.53	16.5	16.5	16.5	16.5	16.3	16.5	16.5	16.10
Surface profile	*0,00*	1,80	1,78	1,94	n/a	1,93	n/a	n/a	2,48	1,97	1,97	2,02
Wall coordinate Racetrack +X	*146,90*	147,02	146,11	147,35	147,37	147,38	n/a	147,04	146,54	146,88	146,89	146,84
Wall coordinate Racetrack -X	*-146,90*	-147,08	-146,26	-147,13	-147,11	-147,10	n/a	-147,24	-146,58	-146,88	-146,87	-146,86
Ø Pole min	*83,52*	83,43	83,38	83,55	83,55	83,55	83,59	83,64	84,56	84,21	84,22	84,25
Ø Pole max	*84,12*	83,46	83,43	83,55	83,55	83,55	83,61	83,73	84,64	84,24	84,25	84,27
Ø Pole mean	*83,82*	83,45	83,41	83,55	83,55	83,55	83,60	83,69	84,60	84,23	84,24	84,26
Average height	*421,40*	421,40	421,35	421,37	409,53	409,53	n/a	409,52	409,52	409,56	403,59	402,25

Pre-series RFDs: Trim Tuning Journey

NRFD02 (Pre-series #2) Trim Tuning details



QCP		NRFD02		mode 1				mode 2				enviroment			Main Body	
QCP	step QCP	Date	Step	f (MHz)	Q_L	df (MHZ)	df/dL (MHz/mm)	f (MHz)	Q_L	df (MHz)	df/dL (MHz/mm)	T (°C)	P (hPa)	h (%)	L (mm)	dL (mm)
0008.QCP.001	16.2	6/22/23	prima del taglio	396.000	6701			746.800	6052			23.7	995	49	421.34	
		6/30/23	dopo reshaping e prima del taglio	396.310	6000	0.310		746.711	4800	-0.089		23.6	988	46		
		7/4/23	dopo reshaping 2 e prima del taglio	397.72	6200	1.410		746.55	4800	-0.161		23.7	994	48	421.34	
	16.6	8/1/23	dopo primo taglio	399.293	5800	1.573	-0.105	747.564	3800	1.014	-0.068	23.9	982	52	406.39	-14.95
		8/23/23	dopo chiusura cianfrini	399.14	5300	-0.153		747.265	3000	-0.299		24	992	54		
		8/23/23	dopo reshaping pole	399.625	5300	0.485		747.126	2600	-0.139		23.2	991	47		
		8/23/23	chiusura cianfrini	399.14	5300	-0.485		747.265	3000	0.139		24	992	54	406.44	0.05

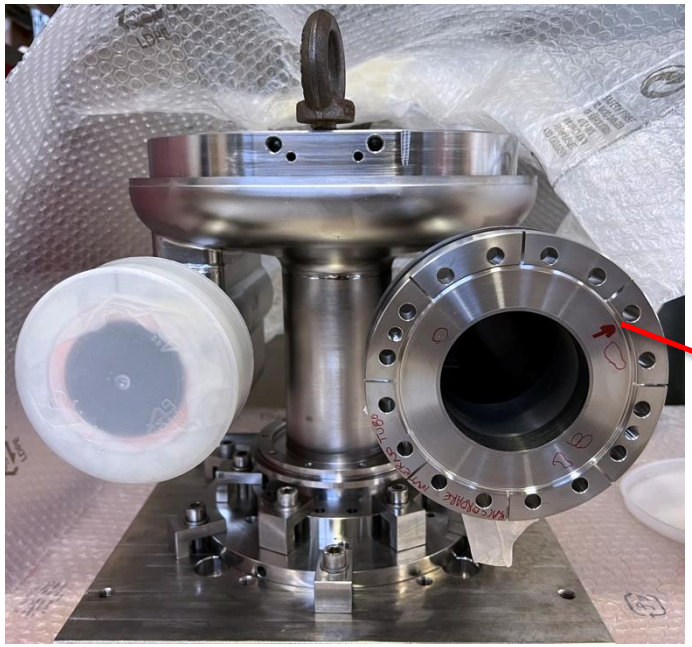
Disegno: Drawing:	**3326.13.000.000** **rev.0**	**QCP**	Z20008.QCP.001
Identificazione: Identification:	**Main Body**	**Cod. Part.:** Item code:	**MBW004**

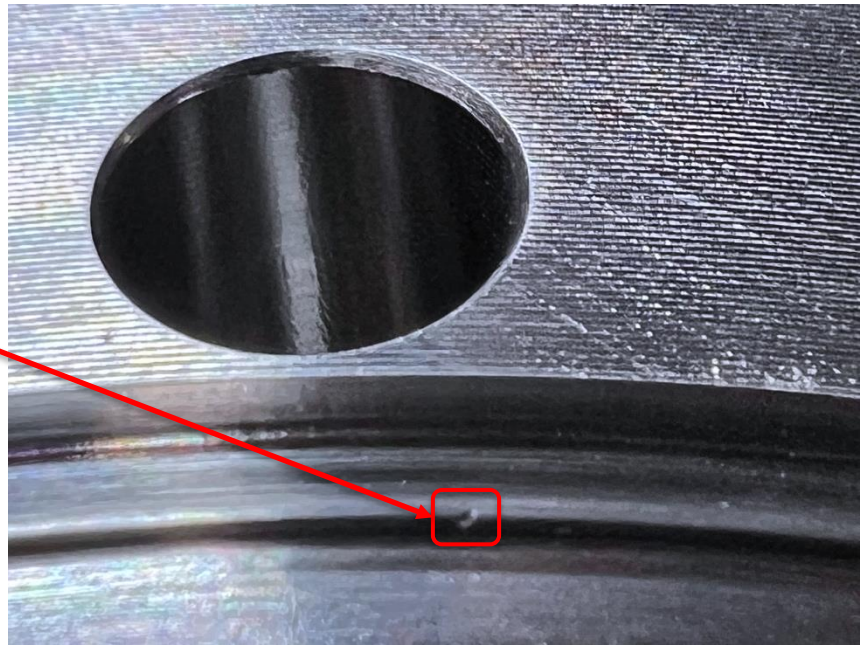
EVOLVING OF DIMENSIONS OF THE MAIN BODY

MBW004	*Nominal*	Before welding the PINs	After welding the PINs	After reshaping	After reshaping [Pole Ø]2	After reshaping [Pole Ø]2.5	After trimming1	After chamfer reshaping + pole reshaping	Before EB welding
Step in drawing	--	2	3	3	3	3	3	3	4
QCP step	--	--	15.49	15.53	15.53	15.53	16.5	16.5	16.10
Surface profile	*0,00*	1,77	1,86	1,89	n/a	2,21	2,20	2,27	
Wall coordinate Racetrack +X	*146,90*	147,30	146,42	147,25	146,98	146,80	146,81	146,71	
Wall coordinate Racetrack -X	*-146,90*	-147,28	-146,32	-147,32	-147,38	-146,74	-146,75	-146,66	
Ø Pole min	*83,52*	82,90	82,95	83,01	83,18	83,94	83,94	84,08	
Ø Pole max	*84,12*	82,98	83,03	83,14	83,26	83,96	83,94	84,09	
Ø Pole mean	*83,82*	82,94	82,99	83,08	83,22	83,95	83,94	84,09	
Average height	*421,40*	421,36	421,33	421,34	421,33	421,34	406,39	406,44	

Pre-series NCRs: H-HOM knife edge case

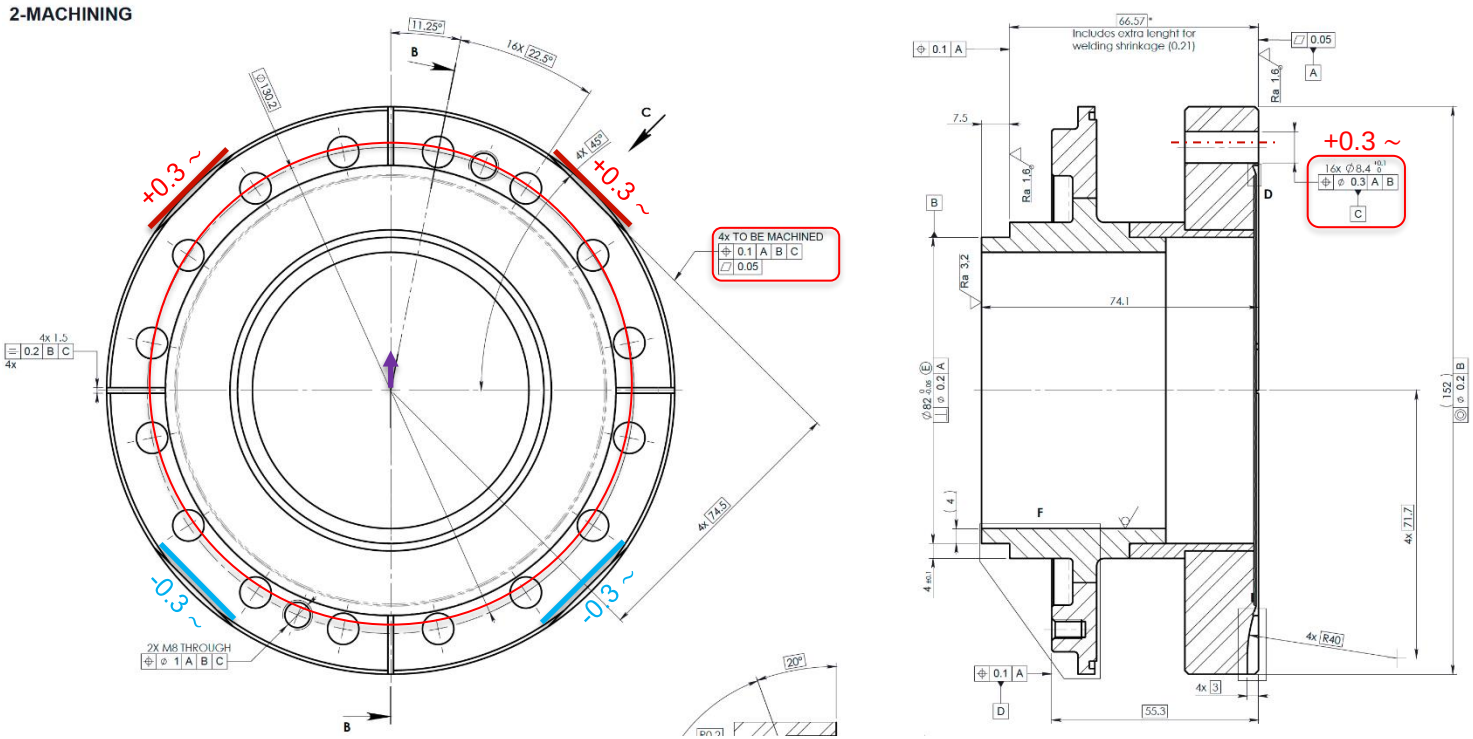
- Unacceptable defect on Knife Edge (depth > 0.2mm)
- Attempts at adjustment provided unsatisfactory results
- A custom-made cutting tool will be used for rework
  - Entire flange plane will be reworked (keep the thickness acceptable)
  - 3+ weeks ETA for procurement of the cutting tool (for vertical lathe)
  - 1 week ETA for CNC machining





Pre-series NCRs: Beam Axis case

- Machining issue on one of the Beam Axis brazed extremity.
- Holes pattern and alignment planes shifted by 0.3mm.
- AUP decided to reject the part. ZRI machined a new one.

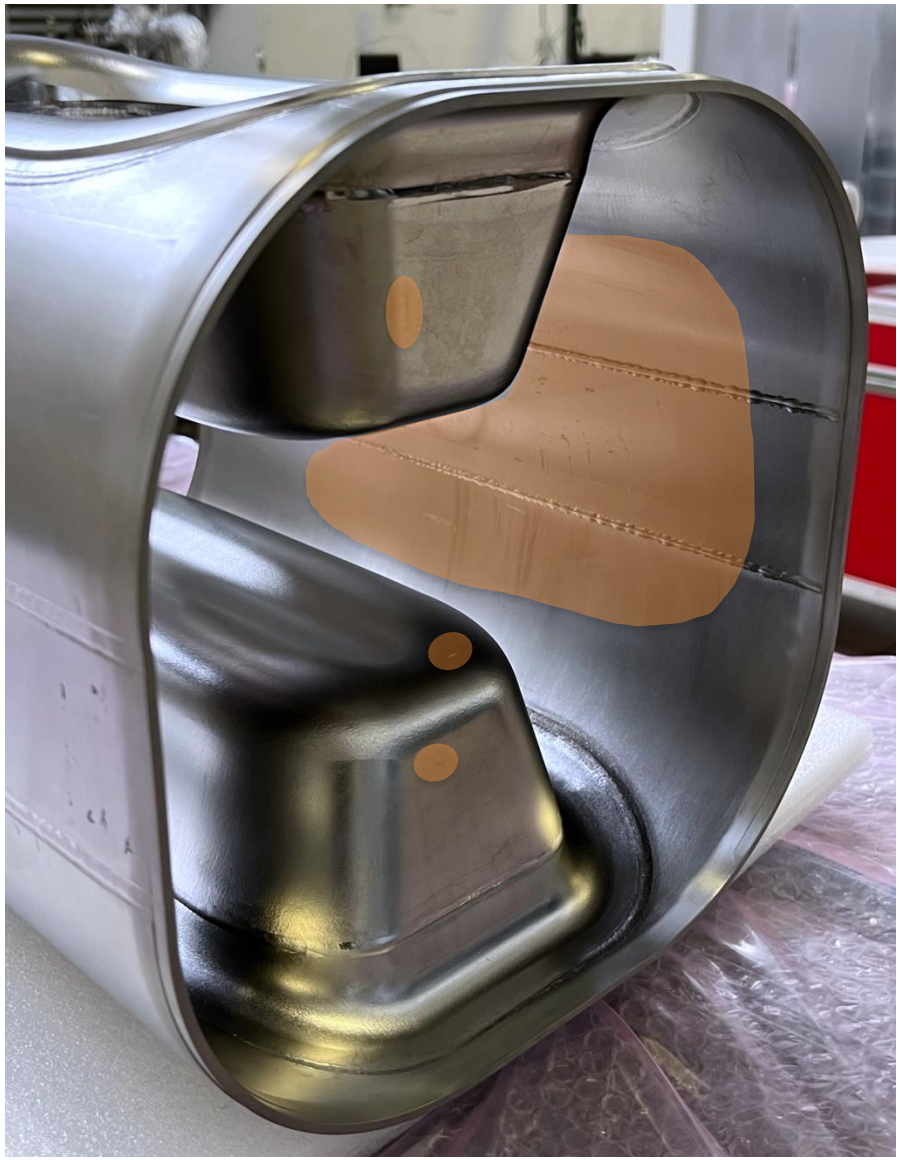


It slowed down production of pre-series cavities for several weeks

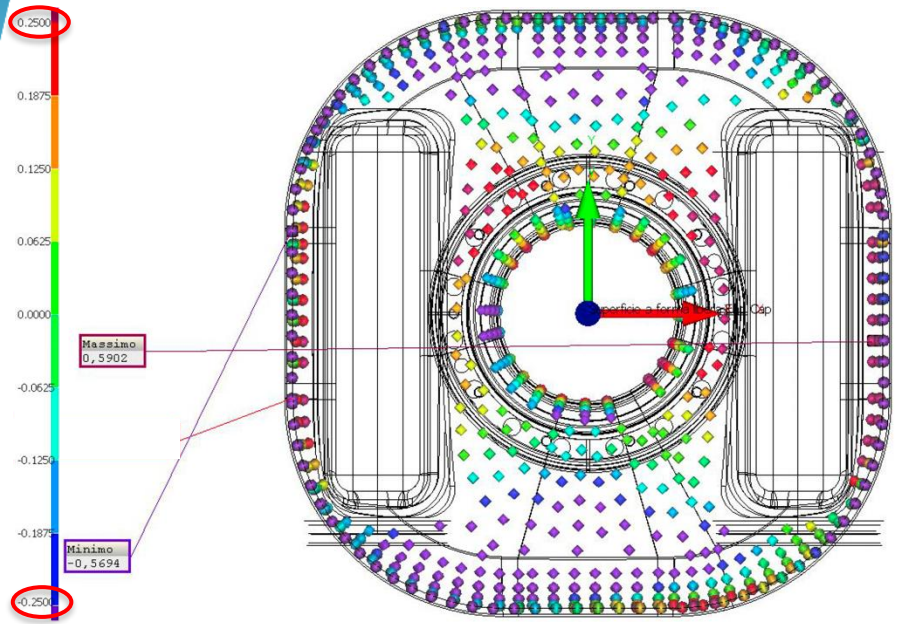
Pre-series NCRs: Main Body case

- After Main Bodies EBW some scratches have been noticed during VT:
  - The root cause was the EBW fixture removal
  - Racetrack RF surfaces was the most affected
  - Minor defects on Poles

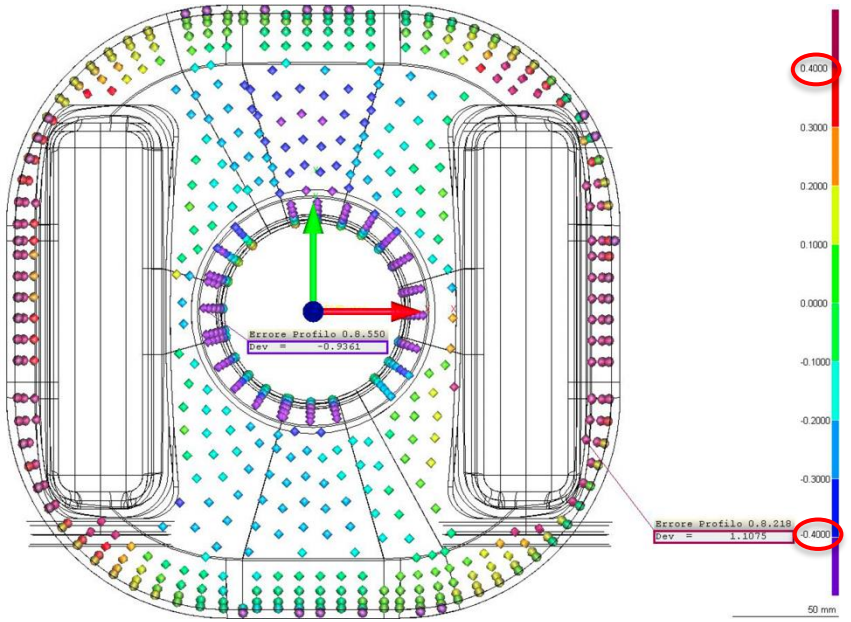
- <u>Countermeasures</u>
  - Re-machining the fixture to avoid future problems
  - Local grinding of the affected RF surfaces (according to the CERN's approved ZRI procedure)



Pre-series vs Prototypes Metrology:
V-HOM End Group



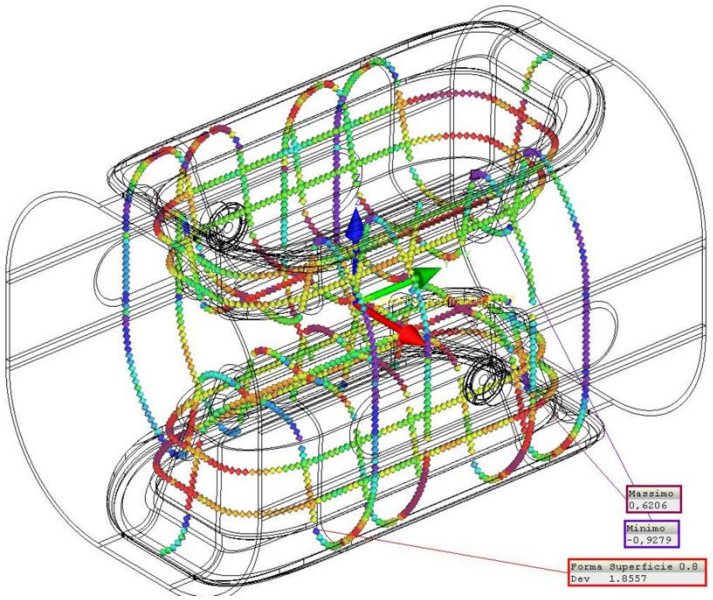
Pre-series V-HOM End Group
{+/-0.25mm scale}



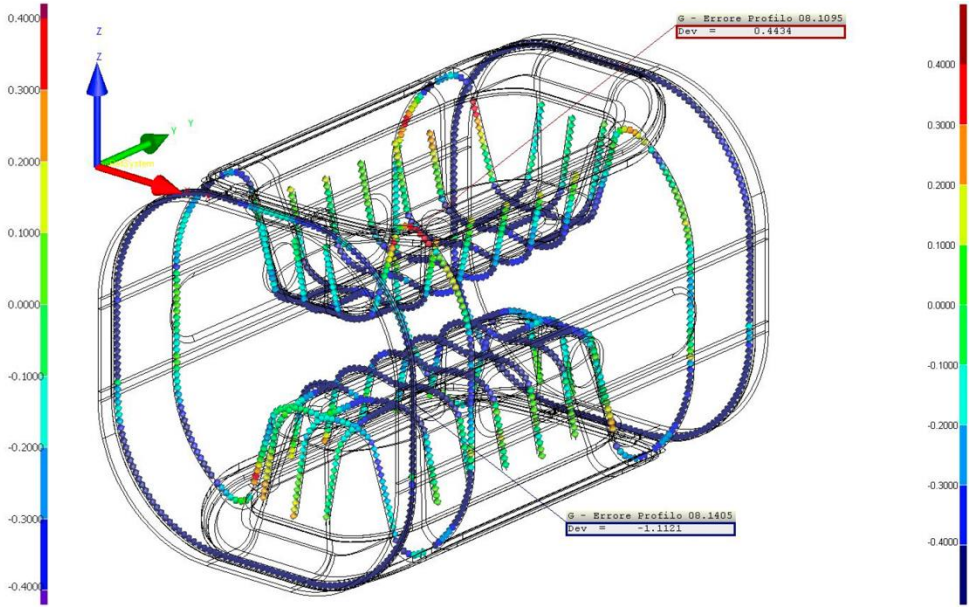
Prototype V-HOM End Group
{+/-0.4mm scale}

- Several improvements in manufacturing have been implemented by ZRI:
  - Forming tooling slightly reworked.
  - EBW and CNC fixtures updated.
- Significant improvement in shape accuracy from 2.22mm to +1.18mm.
- Procedures deriving prototypes have been validated.

Pre-series vs Prototypes Metrology:
Main Body



Pre-series Main Body



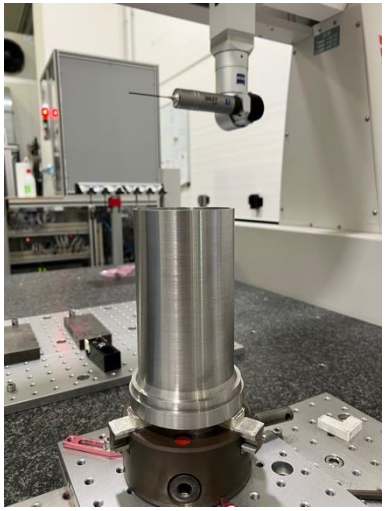
Prototype Main Body

- Effective reshaping of Main Body have been performed by ZRI:
  - Poles and extremity of main body can be reshaped with sub-mm accuracy to enhance the cavity Frequency before final EBW
- Noticeable improvement in shape accuracy from 2.22mm to +1.86mm.
- Procedures deriving prototypes have been revised to improve results

RFD Series manufacturing at ZRI

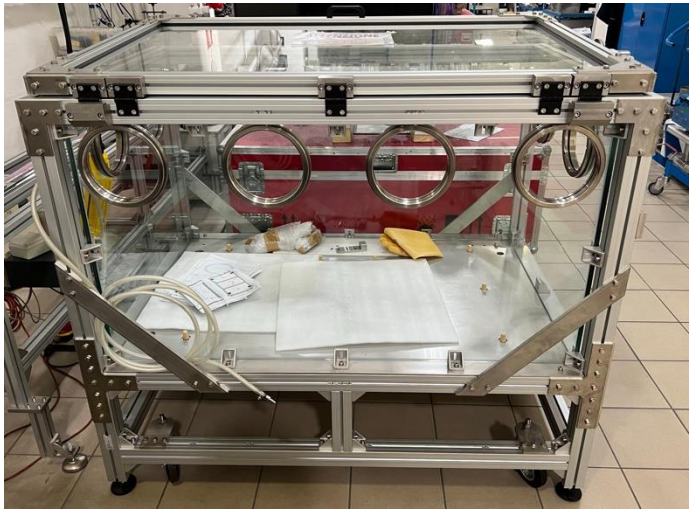
RFD Series manufacturing at ZRI

- Order placed for 10 x Bare RFDs cavities fabrication.
- Full processing for 2 Pre-series + 10 Series Bare Cavities at ZRI.
  - ZRI will perform bulk rotational BCP, HPR, 600ºC + 120ºC bake as EDMS 2901976.
  - AUP increases bulk BCP up to 150µm after prototypes experience
- ✓ All the QA/QC & manufacturing procedures have been already validated.
- FNAL provided all the raw materials.
- Brazed Joints for Series & testing materials have been procured by ZRI
  - Ningxia delayed tubes delivery for months. Brazing qualification will start soon.
  - Brazing Test Plan for Nb/SS extremities is available on EDMS 2910273
- ZRI QCP/ MIP global advancement: 11% completed



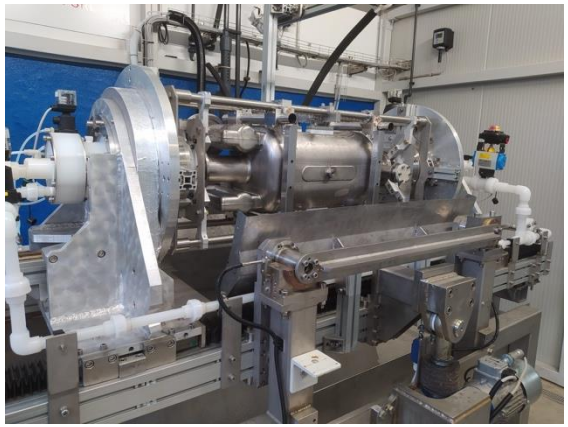
RFD He Tank Prototypes Fabrication at ZRI

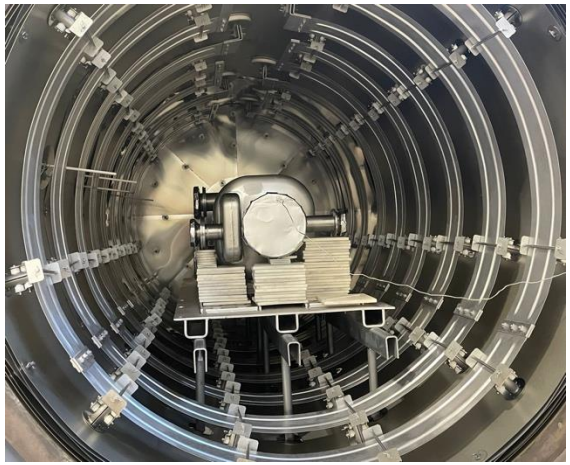
- ZRI is ready to install He Tank onto NRFDP002
  - PO for 11x Series He Tanks will be placed in weeks
- ZRI Dwgs, MIP, Welding Book, Test Plan PQR, LT available on EDMS
  - Ti/SS brazed samples have been qualified EDMS 2917474
  - CERN approval required only for Series fabrication.
- All materials and accessories are available at ZRI.
- NRFDP002 and Magnetic Shields available at ZRI for integration.
- Glove box and internal rotating tool ready to be tested
- Integration is started. ETA first weeks of Nov 2023.



Prototypes Processing at ZRI

- NRFDP001 was clean room assembled
- Totally processed at ZRI (rotating BCP, HPR, 600C, 120C)
- Processing validation still ongoing

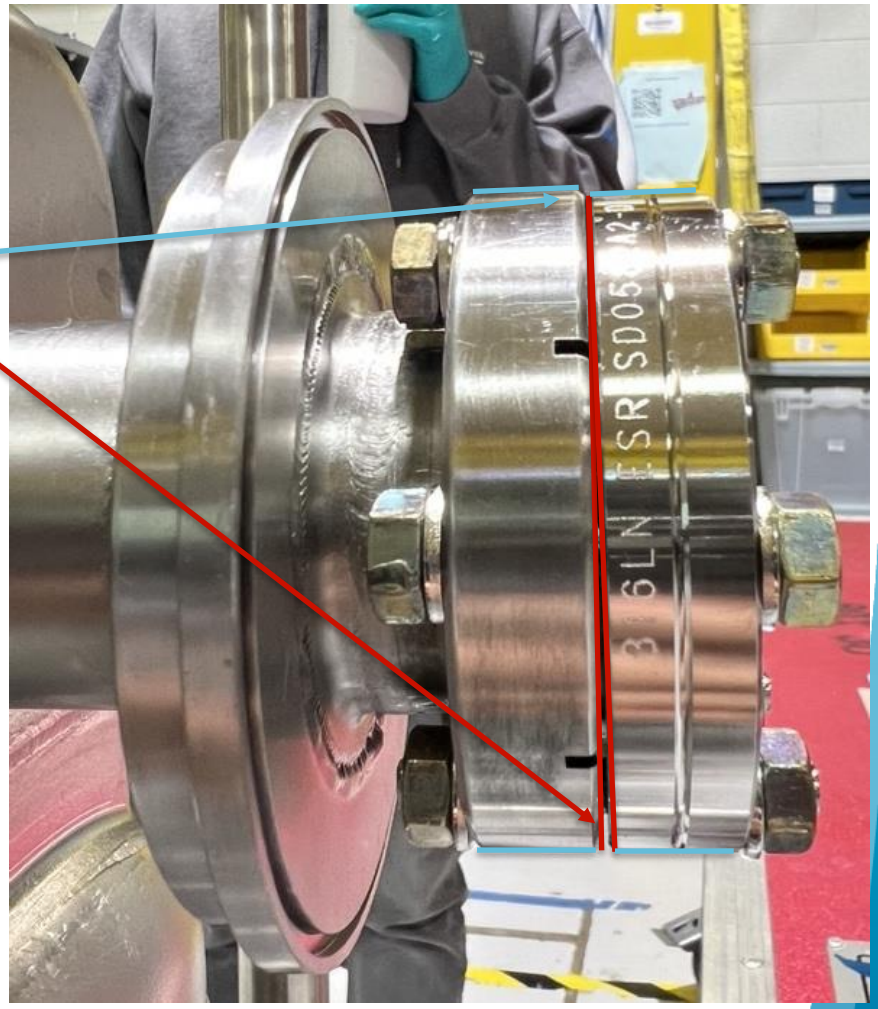



Courtesy of ZRI (confidential)

Prototype NRFDP001:
Clean Room assembly issues at ZRI

- First Cold Test at FNAL: Cold leak at 2K
- VT showed some assembly issues
  - Concentricity cavity flanges/caps
  - up to 230µm of gap (V-HOM side)
- Shipped back to ZRI for a new HPR + updated assembly (witness by FNAL)
- Second VTS at FNAL:
  - ✓ Leak problems: solved
  - Very good Q_0 at low field but FE limited cavity performances
- Next steps: retesting at JLab + some extra NDTs on internal surfaces



Summary & Plans

Raw materials:

All materials are available at ZRI.

Experiencing some issues in Poles and WGs forming with Series mats.

Nb Tubes shipped with months of retards, two required additional NDTs.

RFD Bare Cavities:

2x Prototypes qualified w/wo ancillaries. Exceeded requirements. Processing at ZRI still not completely validated for cold leak issues.

2x Pre-series RFD are being finalized (ETA end 2023). Appreciable improvements compared to the prototypes. QA very close to full approval.

10 x Series RFD manufacturing at ZRI ongoing (11%). Brazing qualification will start in the next weeks.

RFD Jacketed Cavities

2x He Tank Prototypes integration in the next months.

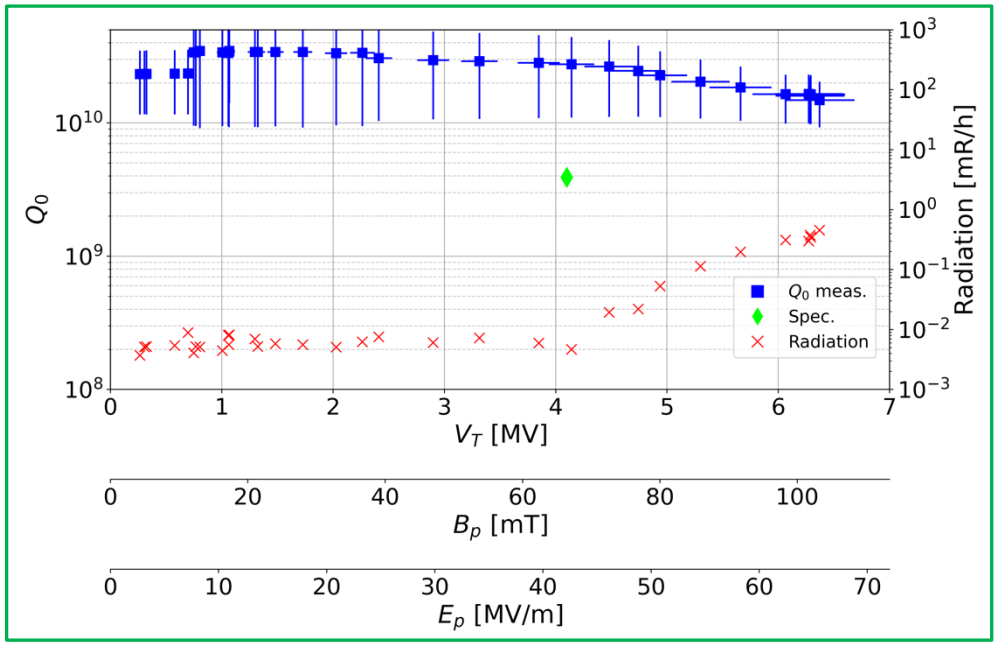
PO for 11x Series He Tanks will be placed in the next weeks.

QA need CERN approval for series production.

Thanks for the attention!

AUP RFD Prototypes Testing

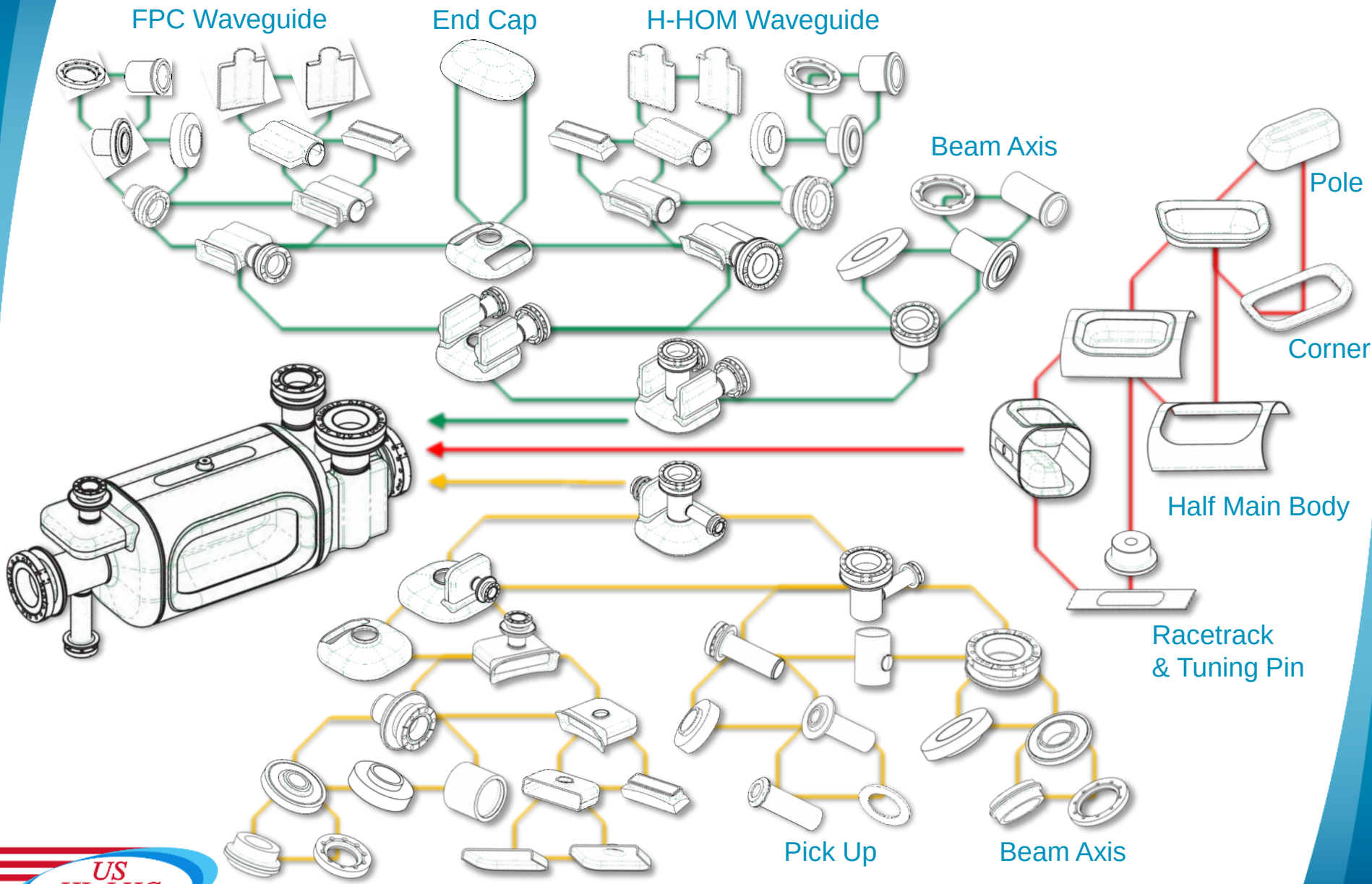
- ✓ 2 x RFD Prototypes manufactured at ZRI to HL-LHC specifications
- ✓ Both cavities (NRFDP001/2) exceeded functional requirements
- ✓ ZRI QA docs, QCRs and Procedures exercised on EDMS/ MTF
- ✓ AUP qualified the cavities via VTS w/wo HOMs (A. Castilla presentation)



VTS @2K of NRFDP002 with ancillaries
Courtesy of A. Castilla (JLab)

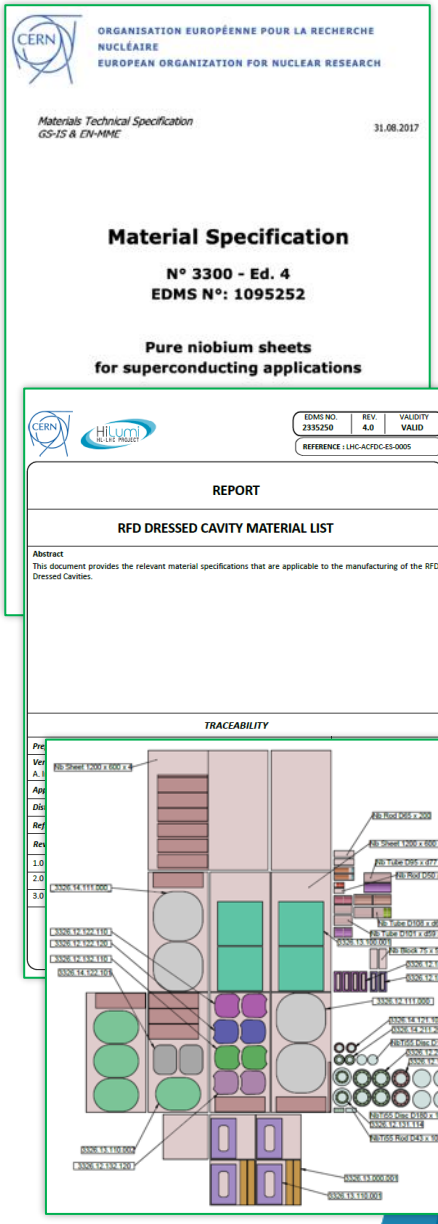
RF check of NRFDP002 without ancillaries
(FNAL)

ZRI Fabrication Strategy



Raw Materials Procurement

- Dressed RFD mat. specs agreed between CERN - AUP
  - ✓ RRR300 Niobium
    - ✓ Sheets – CERN spec. 3300 ed.4 (*EDMS 1095252*)
    - ✓ Bars & Plates – CERN spec. 3301 ed.4 (*EDMS 1476934*)
    - ✓ Seamless Tubes (*EDMS 2367297*)
    - ✓ Ultrasonic Inspection Procedure (*EDMS 1971779*)
  - ✓ Nb-55Ti
    - ✓ Bars & Plates - CERN spec. 4055 ed.4 (*EDMS 1485727*)
    - ✓ Ultrasonic Inspection Procedure (*EDMS 2116737*)
  - ✓ Stainless Steel 1.4429 (316LN)
    - ✓ Forged Blanks - CERN spec. 1001 ed.5 (*EDMS 790775*)
  - ✓ Other materials for Dressed Cavity
    - ✓ (Ti, Cu, SS, Cryophy, Alumina & Gapasil)
- Sizes & quantities optimized by ZRI* after protos experience
- Purchased according to the HL-LHC requirements *(Pre-series & Series production)*
  - ✓ PO 657756 (Ningxia) Nb Sheets
  - ✓ PO 671157 (Ningxia) Nb Rods & Plates, NbTi Rods & Discs
  - ✓ PO 671490 (Ningxia) Nb Tubes
  - ✓ ZRI* PO (Ningxia) additional Nb for welding tests
  - ✓ PO 686821 (ANL) extra brazed joints for pre-series


ORGANISATION EUROPÉENNE POUR LA RECHERCHE NUCLÉAIRE
EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

Materials Technical Specification
GS-IS & EN-MME

31.08.2017

Material Specification

N° 3300 - Ed. 4
EDMS N°: 1095252

Pure niobium sheets for superconducting applications

EDMS NO. 2335250 | REV. 4.0 | VALIDITY VALID
REFERENCE : LHC-ACFDC-ES-0005

REPORT

RFD DRESSED CAVITY MATERIAL LIST

Abstract
This document provides the relevant material specifications that are applicable to the manufacturing of the RFD Dressed Cavities.

TRACEABILITY

* ”Ettore Zanon spa” has changed its name in ZRI: “Zanon Research & Innovation srl”