Q1/Q3 CM and Cryo-Assembly Production Status

Sandor Feher – Fermilab

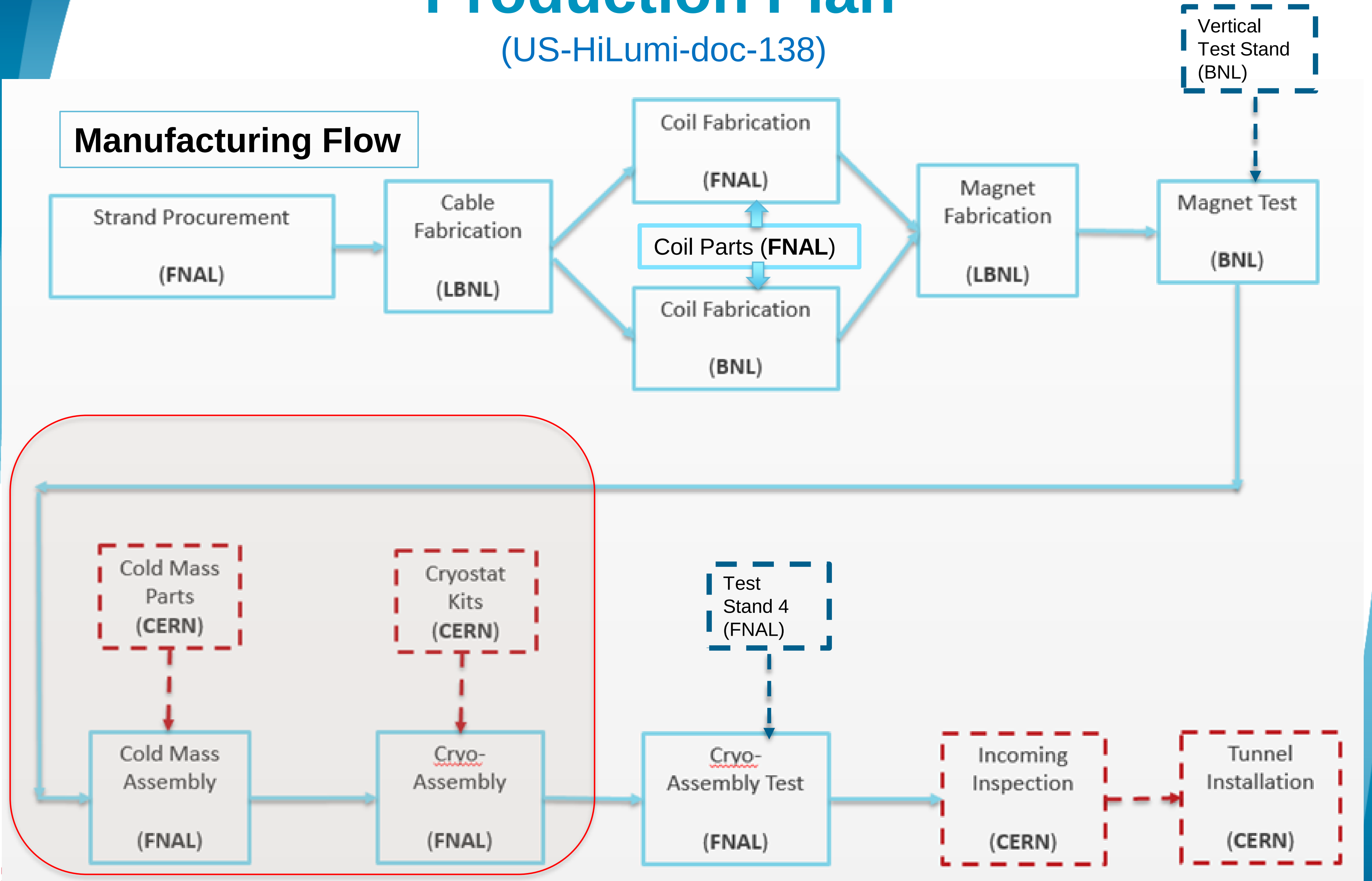
13th HiLumi Collaboration Meeting – Vancouver, September 2023

Outline

- Scope, Functional Requirement Specifications and Acceptance Criteria
- Reviews related to CM&Cryo
- CA01 status
- CM02, CM03 status/progress
- Lesson learned in Cryostating activities
- Schedule

Production Plan

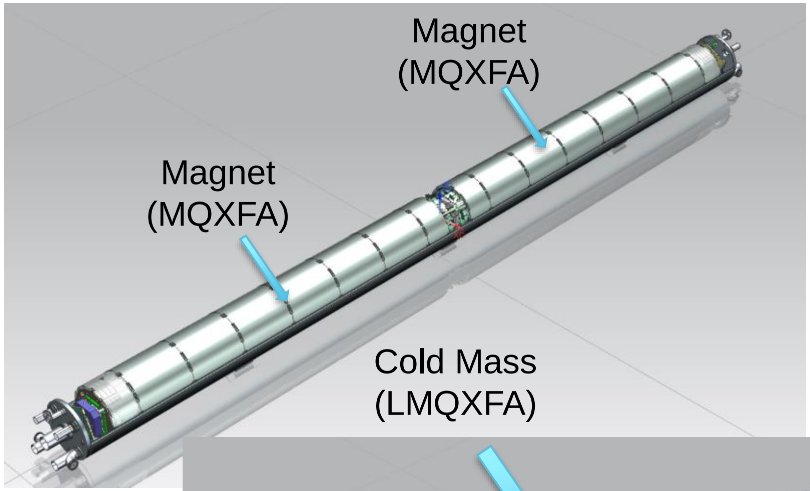
(US-HiLumi-doc-138)

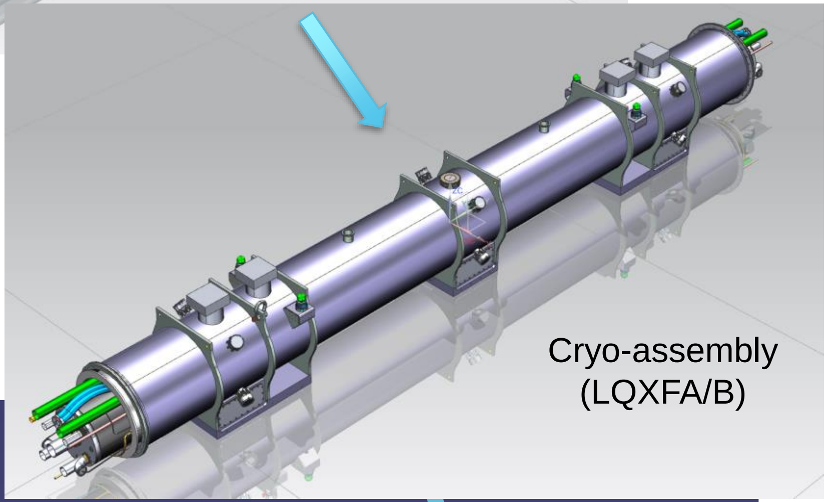


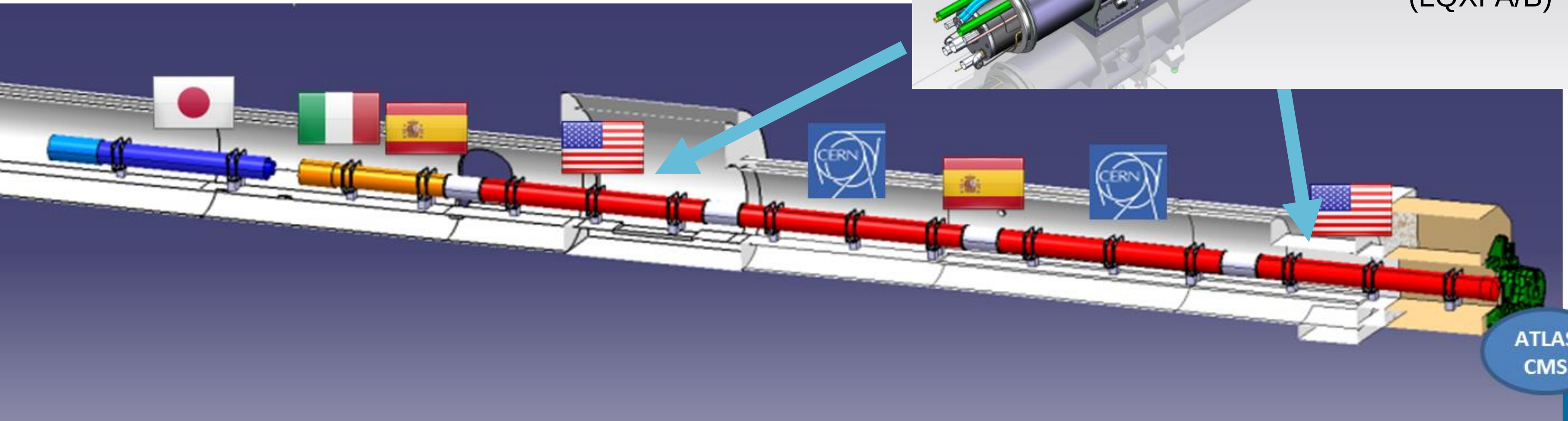
302.4 Scope

12 Q1/Q3 Cryo-Assemblies

- 3 pre-series
- 7 series production
- Re-work of two Cryo-Assembly assumed







Performance Requirements

- **Cold Mass Functional Requirement Specifications (FRS)**
  - CERN approved – EDMS No 1686197 (28/07/2017) under revision control
  - AUP accepted
- Requirements are classified into two groups:
  - <u>Threshold</u> requirements (CM 27) are requirements that contain at least one parameter that the project must achieve.
  - <u>Objective</u> requirements (CM 4) are requirements that the project should achieve and will strive to achieve.
- All requirements are traceable
- Needs an update, new release:
  - Magnetic center separation distance between magnets has changed – based on SSW and rotating coil measurements

EDMS NO.	REV.	VALIDITY
1686197	0.5	DRAFT

REFERENCE : LHC-LMQXFA-ES-0001

US-HiLumi-doc-64

FUNCTIONAL SPECIFICATION

LMQXFA COLD MASS

Abstract

This document specifies the functional requirements for the LMQXFA cold mass readapted for the American contribution. If all the requirements specified in this document are met, then the U.S. HL-LHC AUP LMQXFA deliverables will be accepted by CERN for the HL-LHC project.

Please note that the definition of threshold as it is being used by the American contribution is not the same as objective, according to the HL-LHC quality policy.

TRACEABILITY

Prepared by: R. Carcagno (US LARP), S. Feher (US LARP)	***Date:*** 11/07/2017
Verified by: C. Adorisio, G. Arduini, V. Baglin, M. Bajko, A. Ballarino, I. Bejar Alonso, J. P. Burnet, F. Cerutti, P. Chiggiato, S. Claudet, D. Delikaris, P. Ferracin, P. Fessia, S. Gilardoni, V. Mertens, T. Otto, M. Pojer, G. de Rijk, A. Siemko, L. Tavian, R. Van Weelderen, D. Wollmann	***Date:*** 12/07/2017
Approved by: L. Bottura, O. Bruning , J.M. Jimenez, L. Rossi, E. Todesco	***Date:*** DD/MM/2017
Distribution: US LARP	
Ref. Doc:	

Rev. No.	Date	Description of Changes (major changes only, minor changes in EDMS)
0.5	12/07/2017	Version for verification

Electronic signature on DocDB

Engineering & Equipment Data Management Service (EDMS)

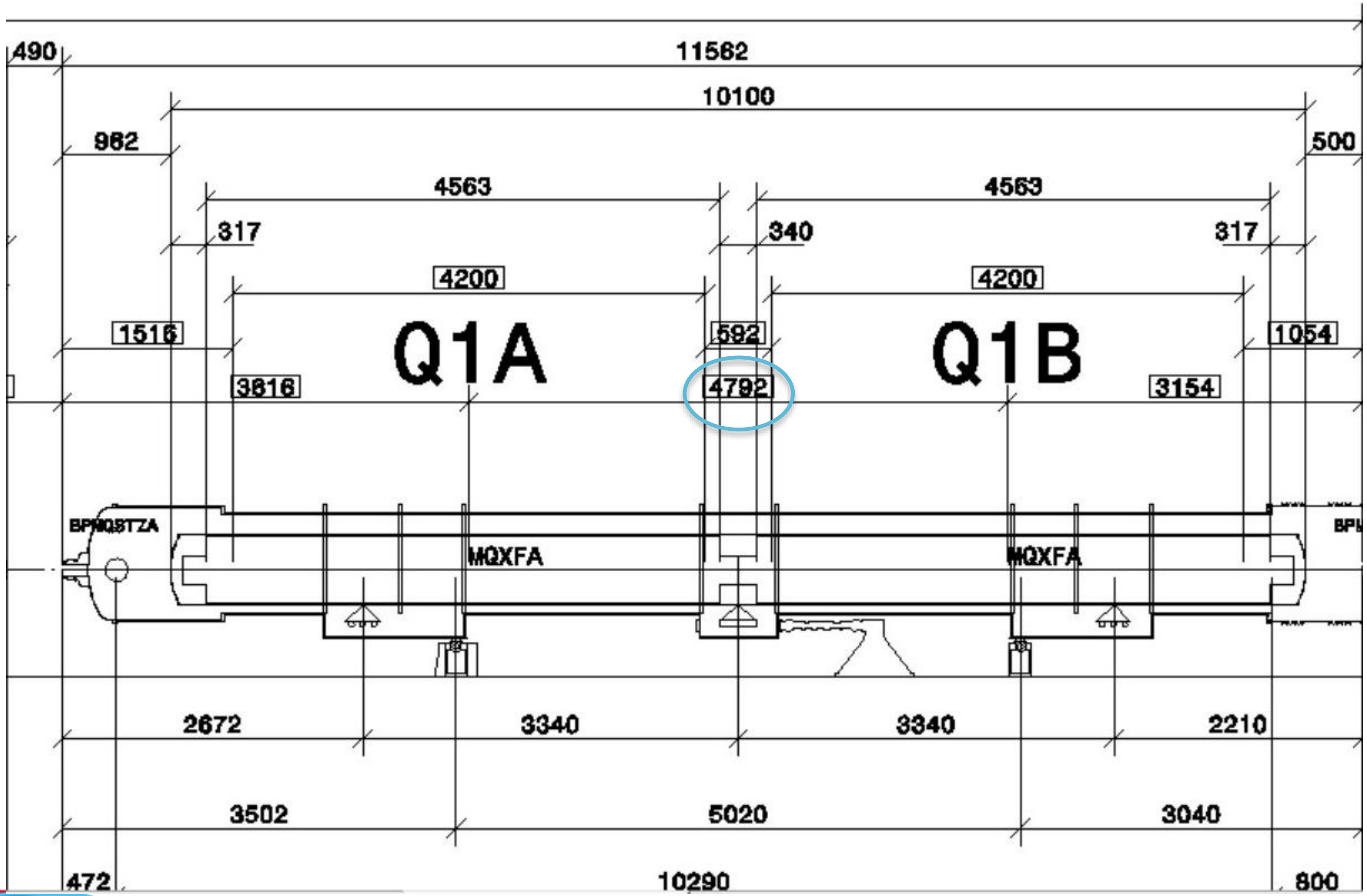
Acceptance criteria

(US-HiLumi-doc-1127)

- Cryo-Assembly acceptance criteria has been developed approved by CERN (EDMS no 2323981) CERN.
- It is based on Requirements documents:
  - Every individual requirement is separately addressed
  - Verification plan was developed for each requirement
- Needs to be updated

FRS and Acceptance Criteria Update

R-T-06: The distance between the two nodal points of the MQXFA magnetic lengths is 4806 mm ± 5 mm at nominal operating temperature (1.9 K).



Reviews

- Design change Review follow up
  - July 2022 the first one, then December 2022
  - Fully accepted by the committee
- DOE review
  - Re-baseline – needed more money
  - Successful review in December 2022
- Shipping post and shipping post tooling review
  - Short but important review ensuring the solidness of the design; high value to be shipped.
  - Conducted in May 2023
- Series Production Readiness Review
  - In early September 2023 conducted
  - Three recommendations

Design modifications due to new/change Requirements

- **Cold Mass design internal interface requirement changed**:
  - The circumferential average interference after welding between the SS shell inner surface and magnet outer surface along each magnet length must be **Delta_C ≥ - 0.2 mm**, resulting in average coil pre-load increase ≤ **3.2 MPa** (old value was 15 Mpa) at room temperature
  - In short spots, for possible local repair, the local **Delta_C must be ≥ - 0.5 mm**, and the average along magnet length must meet the previous specification.

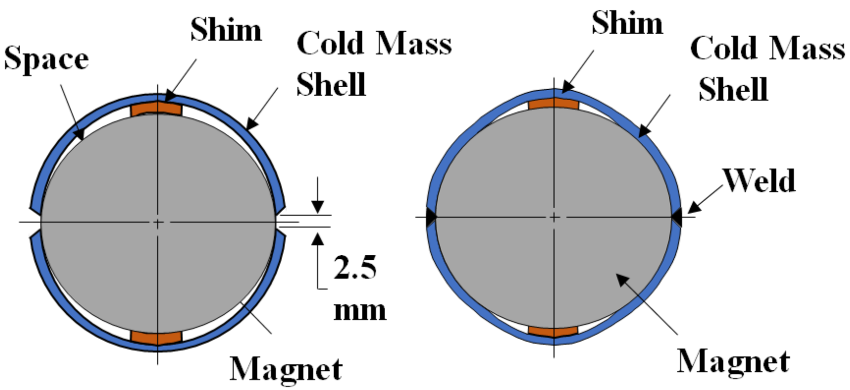
- **New requirement R-T-10b:** The fixed points of the MQXFA magnet shall not move inside the LMQXFA cold mass when subject to 2.5 bar differential pressure between the ends of each MQXFA magnet in accordance with a global pressure gradient of 5 bar linearly distributed over the cold mass length (induced by cryogenic operation or by quench of other magnets [11] version 1.0) and this load shall not introduce any physical damage or performance degradation during the cryo-magnet lifetime

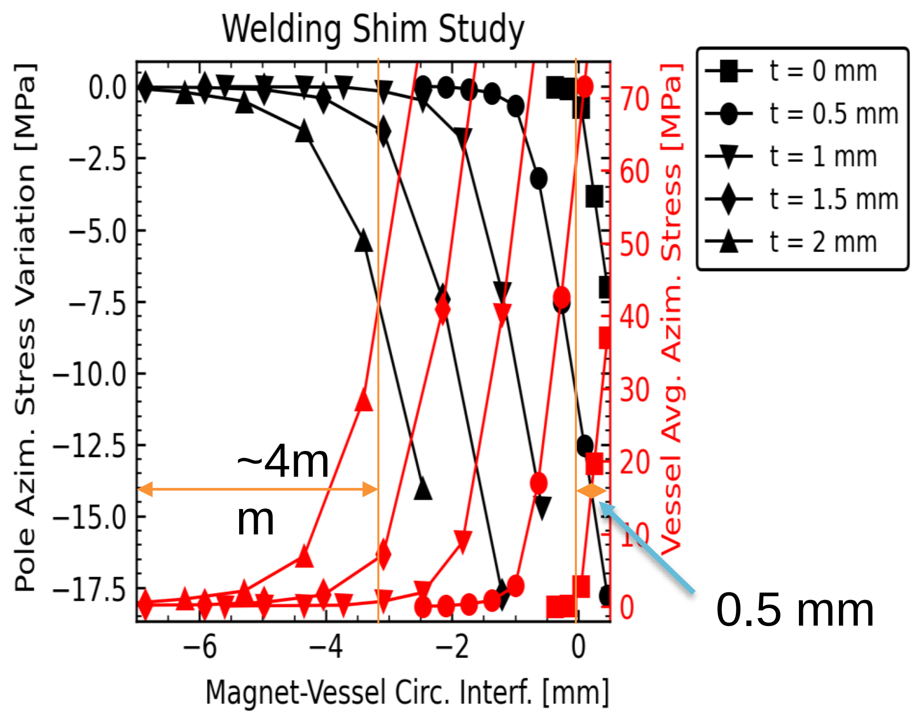
US HL-LHC AUP

Design change

- Accommodating the lower prestress and ensuring that the prestress is always there welding shim design was incorporated.
- Detailed study and paper was presented at ASC2022 by G. Vallone.

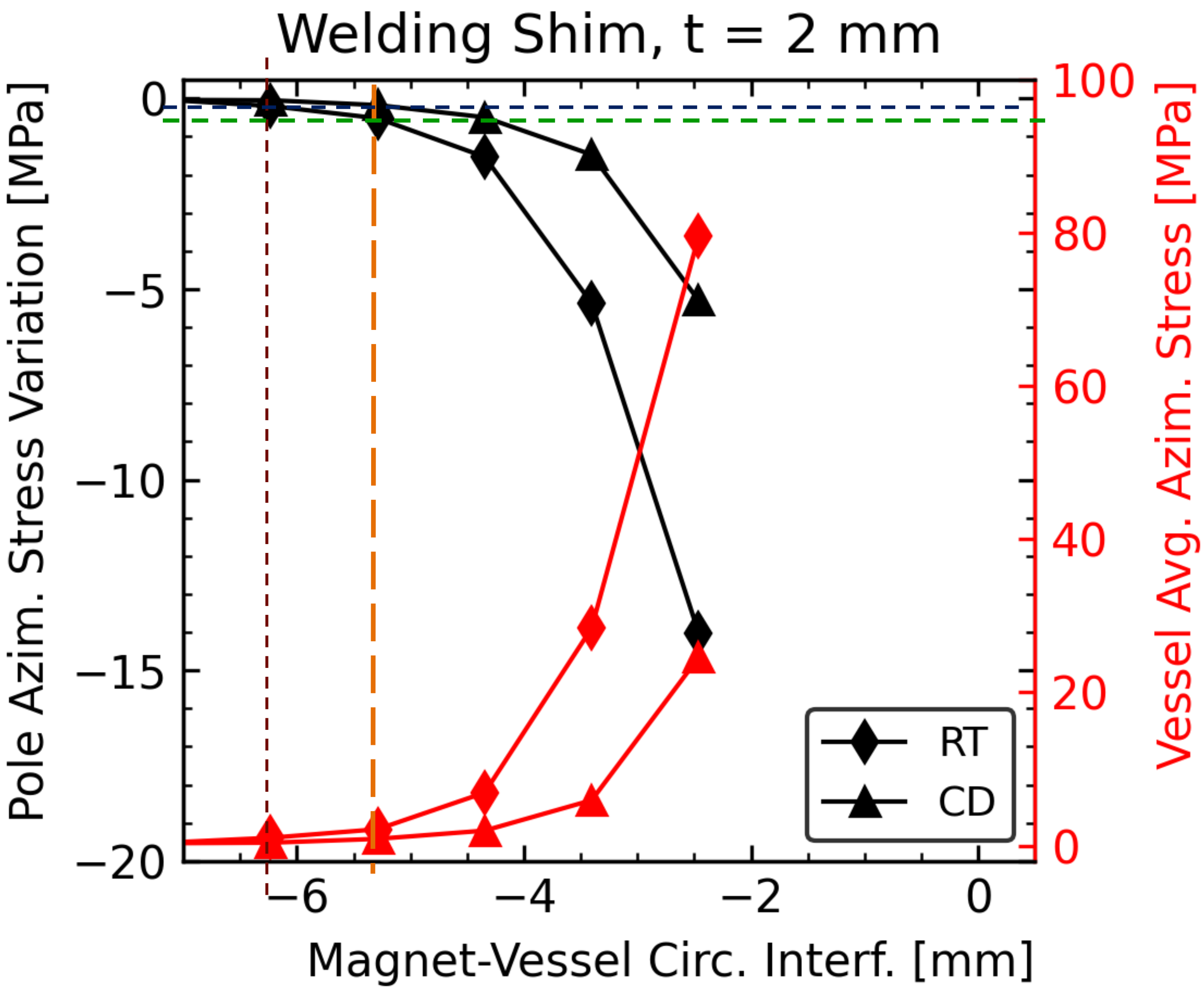
Applied **forces**:
Transportation: 135 kN
Quench/Cryogenic operation:
61.8 kN (2.5 bar pressure wave)
Allowable **pole stress** increase:
-3.2 MPa on the average
-9.6 MPa at any location





- Without shims the 0.5 mm change in the interference generates ~7 MPa coil stress (~40 MPa SS shell stress)
- With 2 mm shim the same stress change requires ~ 4 mm interference change
- This drastically changes the requirement on tolerances

Shim concept



It can work at cold as well maintaining the prestress level to have enough friction to prevent magnet movement wrt the shell

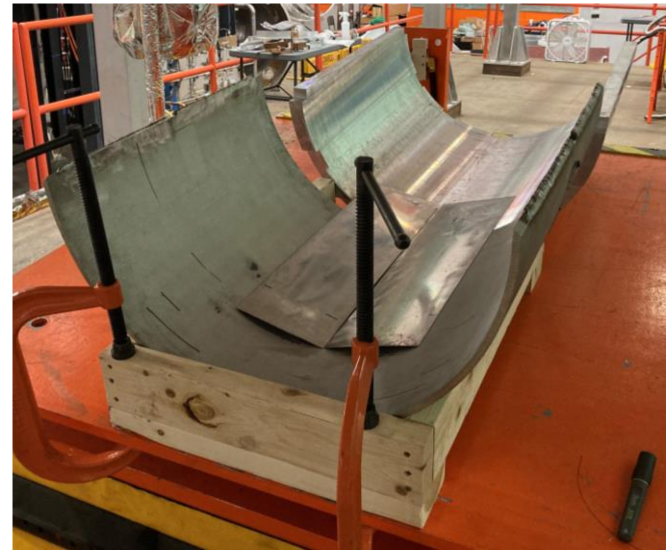
135 kN radial force is equivalent With 0.1 MPa of Pole azimuthal Stress at Cold (CD)

At room temperature > 300 kN radial force

Depending on which Frictional coefficient we are using

Shell Friction Coefficient Proof Test

- To Verify the Friction Coefficient between the Aluminum Shell of the MQXFA Magnet & SS Shells and SS Shims between them we conducted sliding tests:



Test	Trial #1	Trial #2	Trial #3	Avg	$tan\ \theta = \mu$
Alum to SS LHe Shell	23.5°	26°	24°	24.5°	.456
Alum on SS Shims on SS Shell: shims slid on SS	13°	14°	15°	14°	.249
Only SS Shims on SS Shell	13.5°	-	-	13.5°	.24
Alum on SS Shim (fixed)	25°	-	-	25°	.466

Shell Friction Coefficient Proof Test

- **Follow Up Friction Coefficient Test**: Verified the Friction Coefficient between the Aluminum Shell of the MQXFA Magnet & SS He Shell at 80K (LN2) temp.
- Room temperature test repeated (3x) prior to introducing the LN2 bath for reference of smaller samples with possible change
- difference between room temperature and 80K has negligible differences; the friction is getting slightly larger at 80 K

	Delta angle = Cold - Warm				
	Trial #1	Trial #2	Trial #3	Avg	Friction
Alum to SS He Shell	1°	3°	4°	2.6°	0.03

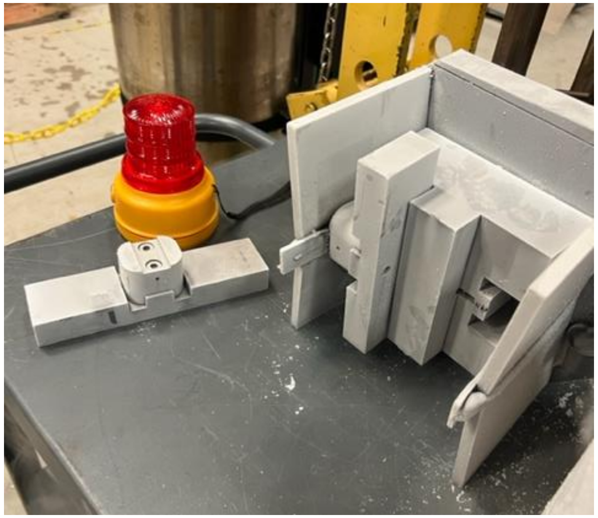
New Tests in LN2 bath

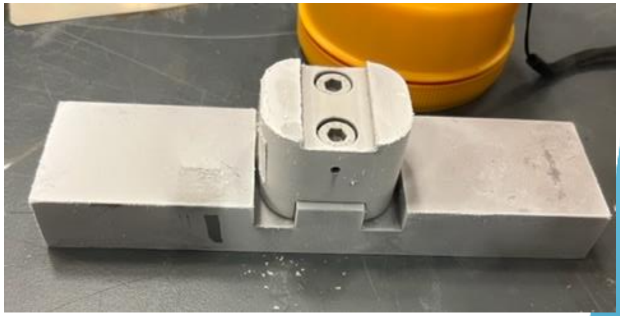
Tack Block Bolt Shear Tests

- Bolt Shear strength Mock-up tests:
  - Original test included a steel mock-up machined with identical bolts and magnet slot details. Tack blocks were bolted using actual bolts procured for the cold mass. Back up strip and plates were welded (per specification) to tack blocks mounted on the mock-up fixture. The IB3 press was used to press plates in increments reaching 80 kN (3x). After 3rd cycle, the pressure was increased in increments again until bolts sheared at a value of 80 kN (17,985 lbs) while holding in preparing to increase to next value.

Cold Tack Block Bolt Shear Tests

- LN2 Bath Bolt Shear strength Mock-up tests:
  - The original fixture was machined to fit the ARMCO Iron inserts provided by LBNL. The inserts were then milled to match the profile of the tack block seat with 2x M8 threaded holes on both faces to mount the tack blocks. Tack blocks were fastened to the ARMCO Iron and fit, welded with the backing strip and shell plates.
  - The Mock up fixture was set in a dewar and filled with LN2 until it cooled down to 80K.
  - The IB3 press was used for this test also raising the load incrementally in 5-10 kN at a time with 30 sec. hold time between steps until failure occurred.





Bolt Shear Results

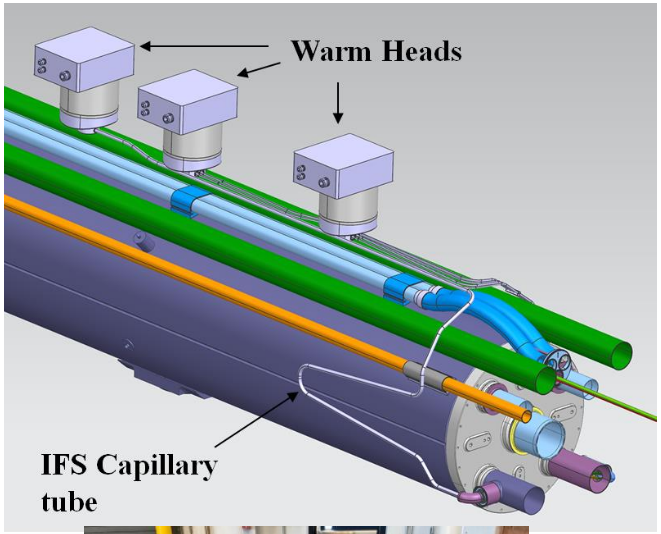
- Result comparison: T(Rm) vs. T(80K)
  - Rm temperature: mock-up fixture reached 80kN prior to bolt shear
  - At 80K temperature: load reached 103.8 kN prior to fixture failure
  - The bolts absorbed 30% higher loads at 80K temperature.
  - Cold re-test planned to achieve true shear value at 80K.

STEP	Force [kN] (LBS)	Press (PSIG)	WARM TEST [kN] (LBS)	COLD TEST [kN] (LBS)	COMMENTS
1	30 (6744.27)	610	30 (6744.4)		
2	45 (10116.4)	910	45 (10116)	49.4 (11111)	
3	62 (13938.15)	1254	62 (13938)	59 (13333)	
4	70 (15736.63)	1416	70 (15737)	69 (15555.4)	
5	75 (16860.67)	1517	75 (16860)	74 (16666.5)	
6	80 (17984.72)	1618	80 (17985)	79 (17777.6)	Warm shear
7	85 (19108.8)	1720	-	84 (18888.7)	
8	90 (20232.8)	1821	-	89 (19999.8)	
9	95 (21356.85)	1922	-	93.9 (21110.9)	
10	100 (22480.9)	2023	-	99 (22222)	
11	105 (23604.9)	2120	-	103.8 (23333)	Cold fixture fai

Series Cold Mass and Cryo-Assembly Production Readiness Review

- Recommendations

1. Create a mockup experiment to precisely model the configuration of heater wires from the coil ends through the cold mass end and capillary tube, including all wire conditions, including lengths inside of and beyond capillary tube, twists, relative separations, routing directions, interruptions due to splices, etc. As part of the experiment, monitor wire tension at the strain relief, if present, or at the coil termination if not, during the process of bending the capillary tube. After bending the capillary tube, begin by providing an open circuit at the coil termination and taking a TDR measurement, and then incrementally shortening the wire length as needed until the value measured on the first cryoassembly is achieved.
2. Effort should be made, and resources allocated to the development of a cold mass disassembly process should the need arise during either continued pre-series or upcoming series production.
3. Prior to any future rework of a cold mass or cryoassembly, conduct a Production Readiness Review of the planned disassembly and rework processes.



CA01 Status

- CM01 was completed last summer, it was reported on the last collaboration meeting and paper was written about the CM01 production (ASC2022)
- Cryostating was completed in late fall and preparation for the horizontal test was completed in December
- Cold Test started in January completed in August
- Received at ICBA This week Monday

Status of Nonconformances/Deviations

- Total of ~180 AUP-internal Discrepancy/Nonconformance reports (integrated for cables, coils, magnets, cold mass and cryo-assembly CA01); most were minor and handled within AUP
- Total of five major nonconformances for which we are working closely with CERN to resolve:
  - EDMS 2515070: "nodal" distance between two magnets out of spec; NCR accepted and closed
  - EDMS 2905753: leak check of CM in the CA was not able to achieve necessary background to verify spec; NCR has been accepted by WP and CERN Vacuum group, and was sent yesterday to HL Project Office for final approval
  - EDMS 2937955: VT EE152 is open; NCR under review by CERN Electrical group
  - EDMS 2769128 and 2883868: two QH failures; NCR under review by CERN Electrical group
- Also one Deviation Request (EDMS 2939701) for CM01 welded to ASME standard (i.e. WPS was not fully qualified to CERN requirements); DR signed by HL project leadership, awaiting approval from HSE

US HL-LHC AUP

Weld/Welder Qualification Updates

- Samples completed and sent out for testing. Samples have now passed all prescribed CERN tests including but not limited to Charpy & Fracture tests at 4.2K
- As of March 2023, 3 FNAL welders passed Welder Performance Qualifications (WPQ) in longitudinal position

Table 1. Test results from 4 K fracture toughness tests.

Weld ID	Notch Direction	Material ID	Sample No.	Kq(J) MPa√m	See Notes Validity Violations
Longitudinal Weld	Longitudinal	Weld	LL-W-1	241	1
			LL-W-2	231	1,2
			Average	236	
		HAZ	LL-HAZ-1	347	2,3
			LL-HAZ-2	347	2,3
			Average	347	
	Transverse	Weld	LT-W-1	238	2,3
			LT-W-2	213	1,2
			Average	226	
		HAZ	LT-HAZ-1	339	2,3
			LT-HAZ-2	322	2,3
			Average	331	
Circumferential Weld	Longitudinal	Weld	CL-W-1	220	3
			CL-W-2	233	2,3
			Average	226	
		HAZ	CL-HAZ-1	324	2
			CL-HAZ-2	n/a	n/a
			Average	324	
	Transverse	Weld	CT-W-1	299	1
			CT-W-2	244	2
			Average	271	
		HAZ	CT-HAZ-1	326	2
			CT-HAZ-2	317	1
			Average	321	

Violation	Description
1	None of nine physical meas of initial crack size to differ by more than .05B from avg a_0
2	None of nine meas of final physical crack size a_p to differ by more than .05B from avg a_p
3	None of nine physical crack extension measurements to be less than 50% of avg crack extension
4	Five valid data points between Δa_{min}, Δa_{limit} and J_{limit}
5	Optically measured a_0 may not differ from calc'd a_{0q} by more than the greater of 0.1W or 0.5 mm

Weld/Welder Qualification Updates

Results and Discussion:

Meeting all the ASTM validity requirements rarely occurs in 4 K "J tests" but depending on the specific violations, the Kq can be used to estimate the toughness of the material. The violations encountered here were relatively minor and unavoidable due to specimen size. The violations were related to specimen size, crack length and crack front straightness requirements.

The probably more important test parameter is the physical behavior of the test specimen and material being tested. The samples were successfully pre-cracked approximately 2 mm of length past the notch tip at 77 K prior to the fracture toughness test at 4 K. During the 4 K toughness tests, a plot of J vs Δa is constructed as shown in Figure 3 (circumferential weld specimen CL-W-2). Ductile materials exhibit an initial linear slope of the "J vs Delta a" data referred to as the blunting line before a change in slope occurs where stable crack growth is observed (tearing modulus). The intersection of the two slopes is a measure of toughness - a materials resistance to crack growth in the presence of the flaw (crack) and the application of constrained stress. Tough materials have a high resistance to the crack growth and low toughness materials either exhibit a low J value or catastrophic failure prior to stable crack growth.

The test results are shown in Table 1. The materials exhibited excellent fracture toughness and resistance to fracture in the presence of complex stress and a prescribed flaw.

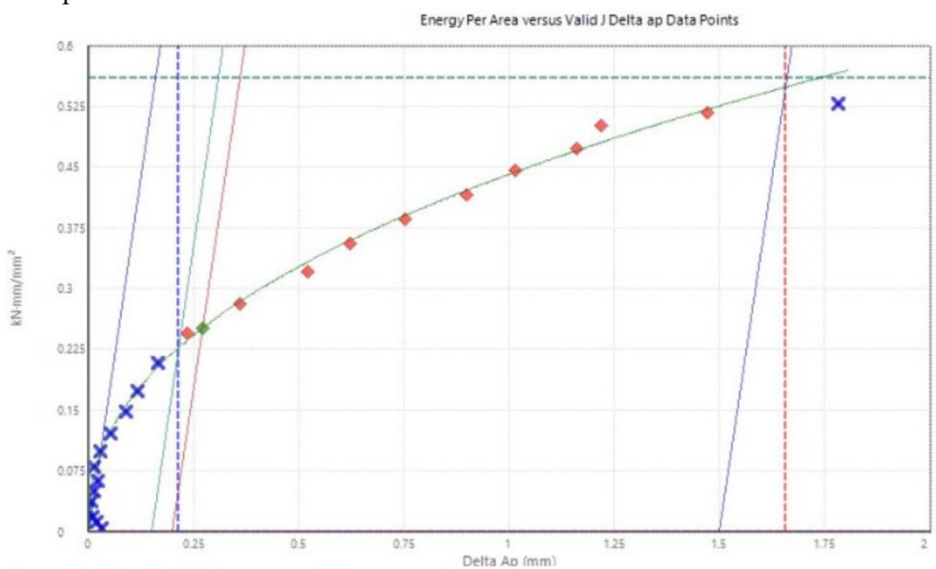


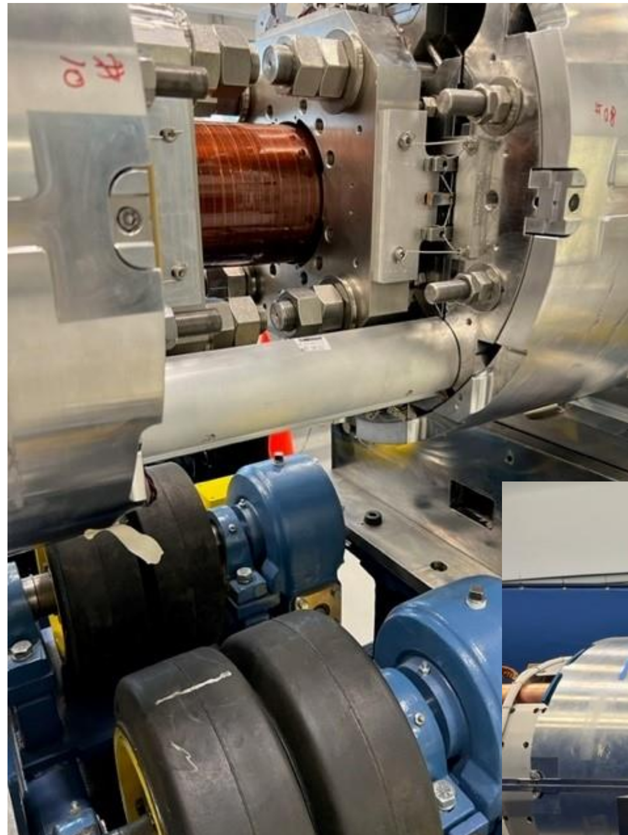
Figure 3. Plot of 4 K J test of weld specimen CL-W-2.

Weld/Welder Qualification Updates

- 3 new Fronius Machines have been procured to assist with longitudinal and Circumferential Welding.
- New Machines record and provide report of welding parameters

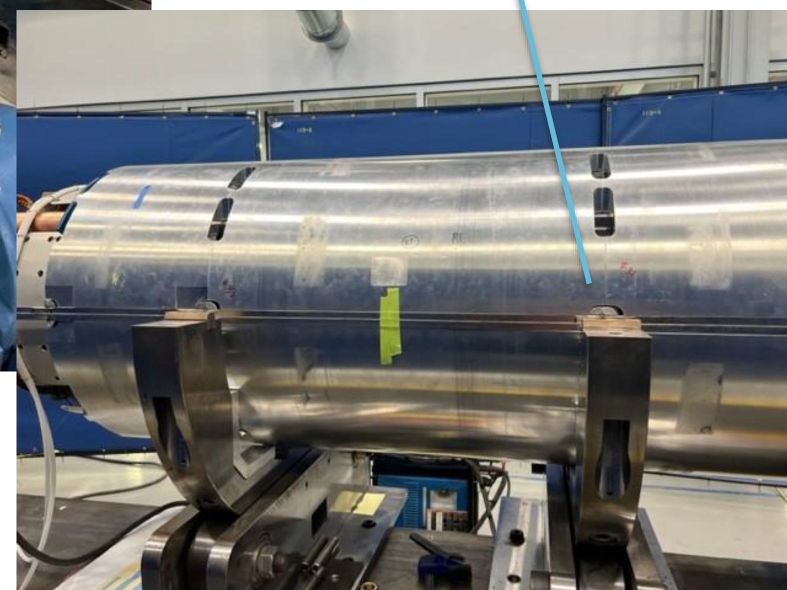
LMQXFA-02 Cold Mass Assembly

- Beam Tube, Heat Exchanger Bus Installation complete
- Backing strip installed w/ tack blocks properly shifted
- New Machining procedure improved tolerances



Beam Tube & Bus Installed

Sliding tack block offset



Tack Block/Backing Strip Installation

LMQXFA-02 Cold Mass Assembly

- New Shell Machining procedure improved results
- Shell Preparations with Shims
- Shell Fit Up completed

Shell Machining

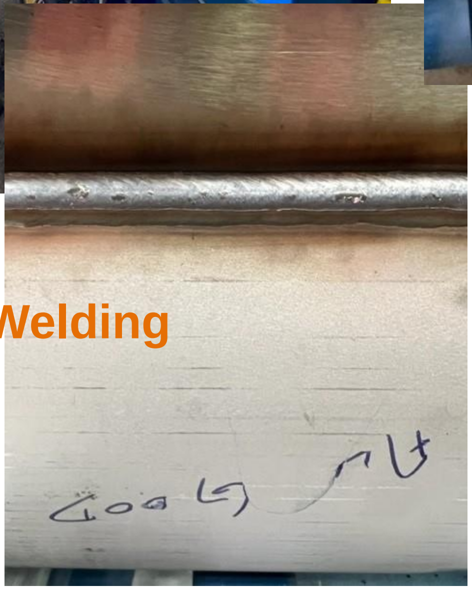
Shell/Shim Prep

Shell Fit Up

US HL-LHC AUP

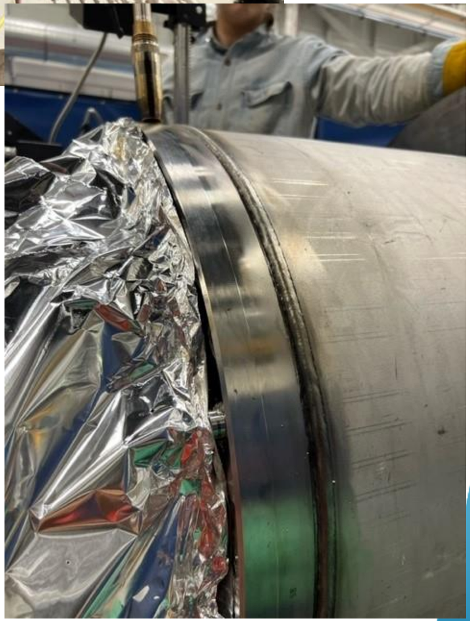
LMQXFA-02 Cold Mass Assembly

- Shell Longitudinal Welding
- Shell Circumferential Welding



Shell Welding

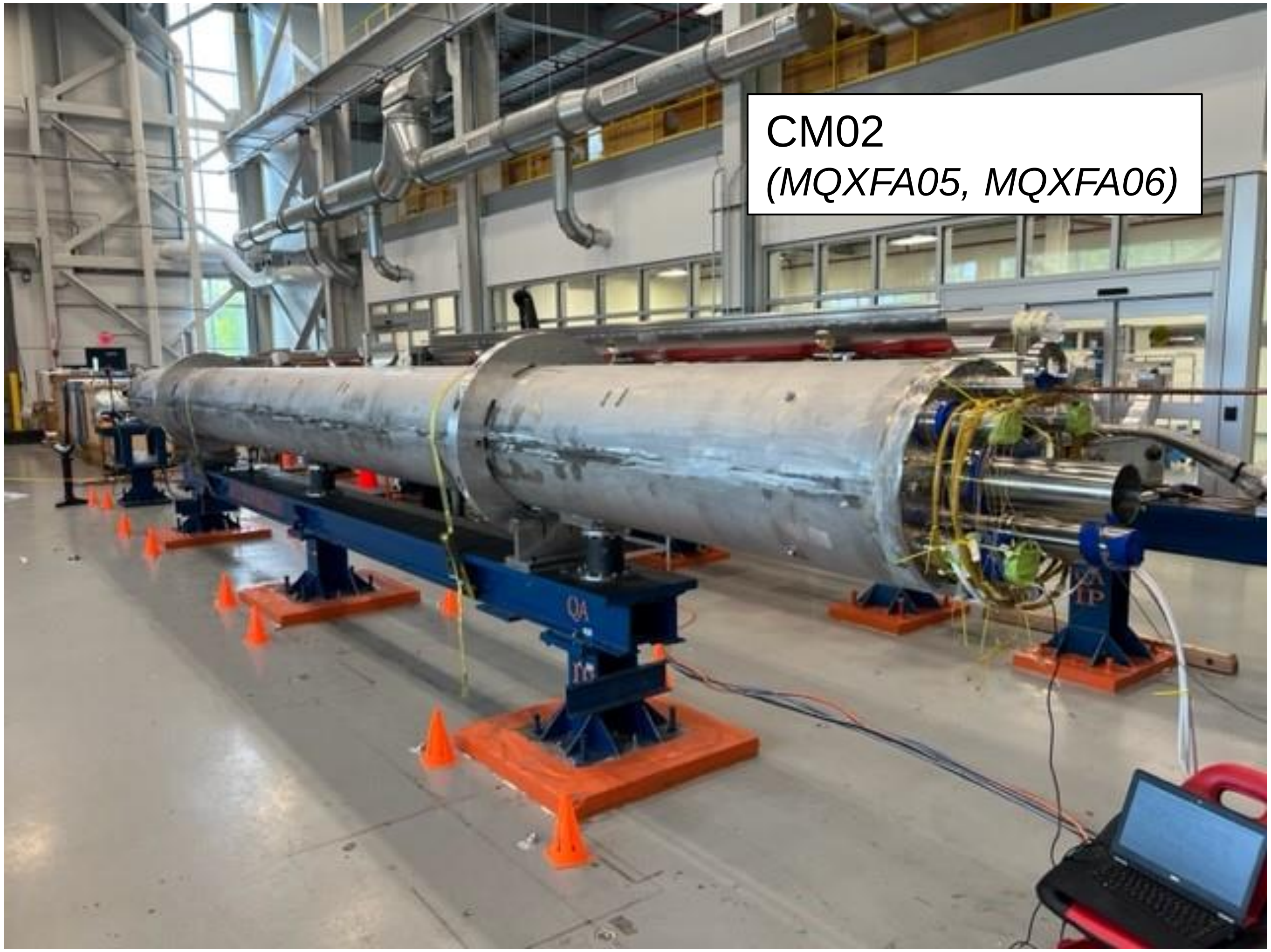
End Cover Fit Up



End Covers Welded

LMQXFA-02 Cold Mass Assembly

- Preparation For Saddle and Nozzle Welding



Inspection prior to Saddle Welding – PAUT Complete

Long & Circ Phased Array Ultrasonic Test

- LMQXFA-02 Long. & circ. welding PAUT – complete
- No Defects found

IRIS NDT

ULTRASONIC INSPECTION REPORT

Report Number: HAA2365228

Page: 1 of 12 Date: 09/12/2023

Client: Fermin Lab Accelerator Laboratory Job #: HAA2365228
Location: Hammond, IN WO #:
Unit #: Shop Item Inspected: LMQXFA Cold Mass Vessel #2

Procedure: ☒ NDE 4.0 Manual UT R10 ☐ NDE 22.5 PAUT-Piping R10 ☒ NDE 22.6 PAUT-Vessel R9
☐ NDE 23.0 TOFD R8 ☐ NDE 22.0 Storage Tank R2 ☐ NDE 4.3 Manual UT R6
Code: ASME SEC VIII Div. 2 Para 7.5.5, Fracture Mechanics.

Material: SS **Thickness:** 0.500" **Surface condition:** ☐ Buffed ☐ Machined ☐ Sand blasted ☐ Ground ☐ Painted ☒ Other As Weld
Heat Treatment: N/A **Surface temp.:** ☐ < 40°F ☒ 40°F - 140°F ☐ >140°F
Scanning surface: ☒ O.D. ☐ I.D

Technique: ☒ Manual UT ☒ PAUT ☐ TOFD **Type:** ☒ P/E ☐ Pitch-Catch ☒ PA **Method:** ☒ Contact ☐ Other

Instrument: (Olympus-NDT) ☐ OmniScan MX2 ☒ OmniScan X3 S/# : QC-0031782 Cal due: 04/03/2024 Software: OmniPC 5.12.0 Version: 5.12.0
☒ EPOCH 650 ☐ EPOCH 600 S/# : 170340102 Cal due: 06/26/2024 Module S/#:

Scanner : ☐ ODI ☒ Microbe ☐ Navic ☐ Circ it **Cables:** ☒ Coaxial cable ☒ 6' (Standard) ☐ Other
Encoder Cal. : 20" (minimum 20") ☐ Mini-Encoder **Couplant:** ☒ Potable Water ☒ Ultra-Gel II (Sonotech)
Scan Resolution : ☒ 0.040" (< 3" T) ☐ 0.080" (> 3" T) ☐ Others ☐ Other

Reference Block : Rompas SS (13-2873) **Calibration block :** ☒ ASME Sec. V 0.500" Basic ☒ Other : SS Navship (67039)

Search unit

Manufacturer	Type	Serial #	Freq. (MHz)	Number of Element	Size of Element	Pitch	Gap	Active Aperture	Angular Range used	Angular Incremental change	Range of Element # used	Element Incremental change
Olympus	5L16	N3317	5	16	0.52mm	0.6mm	0.08mm	9.6mm	40-70	1°	--	--
Olympus	DL4R	1136386	4	1	3.5x10mm	--	--	--	0	--	--	--
---	---	---	---	---	---	---	---	---	---	---	---	---

Wedges			Calibration									
Manufacturer	Part Number	Refracted angle	Reference level gain	Scanning Level gain	Transfer Value	TCG/ DAC	Reference Flaw Type	Reference Flaw size	Focal depth	Damp. (Ohm)	Reject.	PCS (TOFD)
Olympus	SA10-N55S	55	10.3dB	+6dB	0.0 dB	TCG	SDH	3/32"	1.5WT	50	0	--
---	Contact	0°	38.9dB	+6dB	---	---	BWE	75%	---	100	0	--
---	---	---	---	---	---	---	---	---	---	---	---	---

Scope of Work:

Perform PAUT Inspection, Manual UTSW and Manual Ultrasonic straight beam (MUT) as a weld quality on the LMQXFA Cold Mass Vessel #2.

Scan Layout

See page 2 for scan plan

Inspection Results:

PAUT was performed on the welds of the LMQXFA Cold Mass Vessel #2. Manual UTSW transverse and UT 0° lamination scans were also performed providing full-volumetric coverage of the weld, HAZ and base metal. See the results in the table below.

Unit:	Item:	Hrs.	Technician (print): Jhonatan Pereira **SNT-TC-1A Level:** II APIQUTE/QUPA
In:	Out:		Technician (sign): Jhonatan Pereira
In:	Out:		I am in full agreement with report contents.
Personnel:			Client Representative:

IRISNDT TEL 713-722-7177 FAX 713-722-7677 ASME Code Sect. V 2022 T-492. III-492. IV-492 & V-492

IRIS NDT

ULTRASONIC INSPECTION REPORT

Report Number: HAA2365228

Page: 2 of 12 Date: 09/12/2023

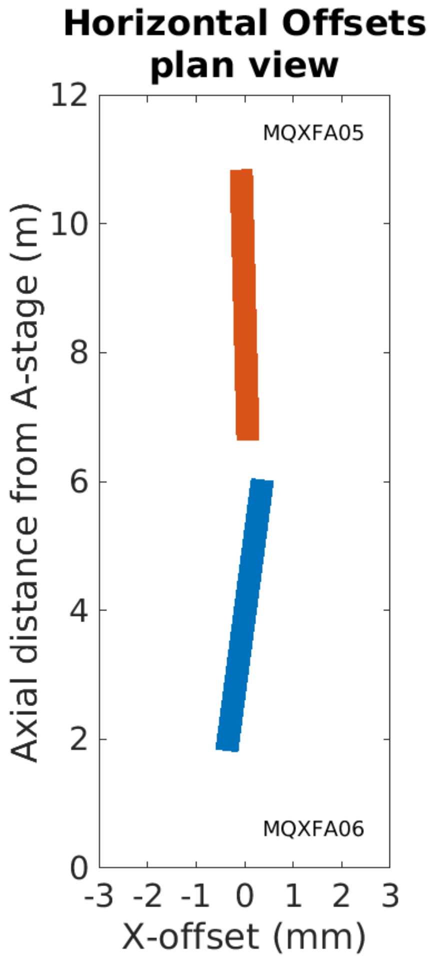
Client: Fermin Lab Accelerator Laboratory Job #: HAA2365228
Location: Hammond, IN WO #:
Unit #: Shop Item Inspected: LMQXFA Cold Mass Vessel #2

Evaluation results for each scan are tabulated in the next table below:

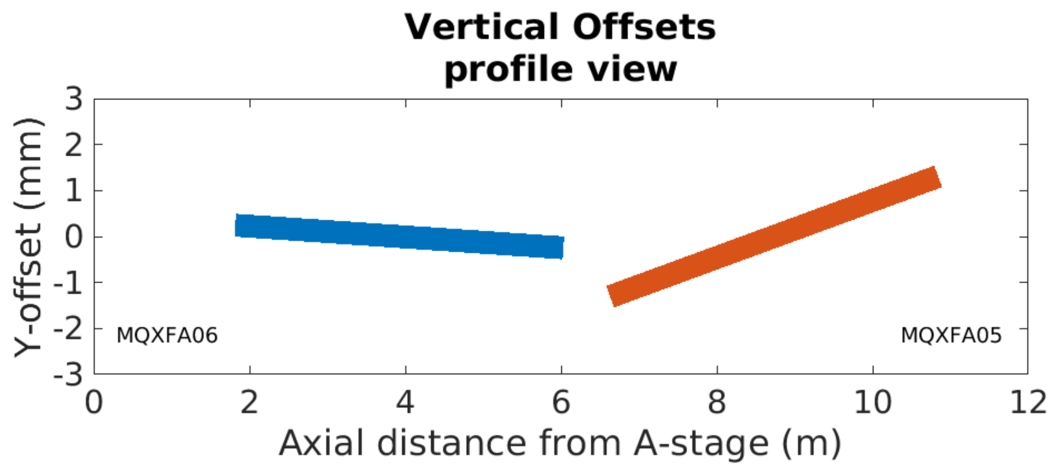
Weld	Scan #	Indication #	Location(in)	Length (in)	Height(in)	Depth(in)	Categorization	Result	Fig.
L1	L1-90T S1	--	--	--	--	--	--	Accepted	
	L1-90T S2	--	--	--	--	--	--	Accepted	
	L1-90T S3	--	--	--	--	--	--	Accepted	
	L1-270B S1	--	--	--	--	--	--	Accepted	
	L1-270B S2	--	--	--	--	--	--	Accepted	
	L1-270B S3	--	--	--	--	--	--	Accepted	
L2	L2-90T S1	--	--	--	--	--	--	Accepted	
	L2-90T S2	--	--	--	--	--	--	Accepted	
	L2-90T S3	--	--	--	--	--	--	Accepted	
	L2-270B S1	--	--	--	--	--	--	Accepted	
	L2-270B S2	--	--	--	--	--	--	Accepted	
	L2-270B S3	--	--	--	--	--	--	Accepted	
C1	C1-S1-90L	--	--	--	--	--	--	Accepted	
	C1-S2-90L	--	--	--	--	--	--	Accepted	
C2	C2-S1-270R	--	--	--	--	--	--	Accepted	
	C2-S2-270R	--	--	--	--	--	--	Accepted	

Cold Mass 02 Alignment

Alignment Relative to MQXFA06/MQXFA05 Average Center Line
27Sep2023 - back to shimmed inspection table



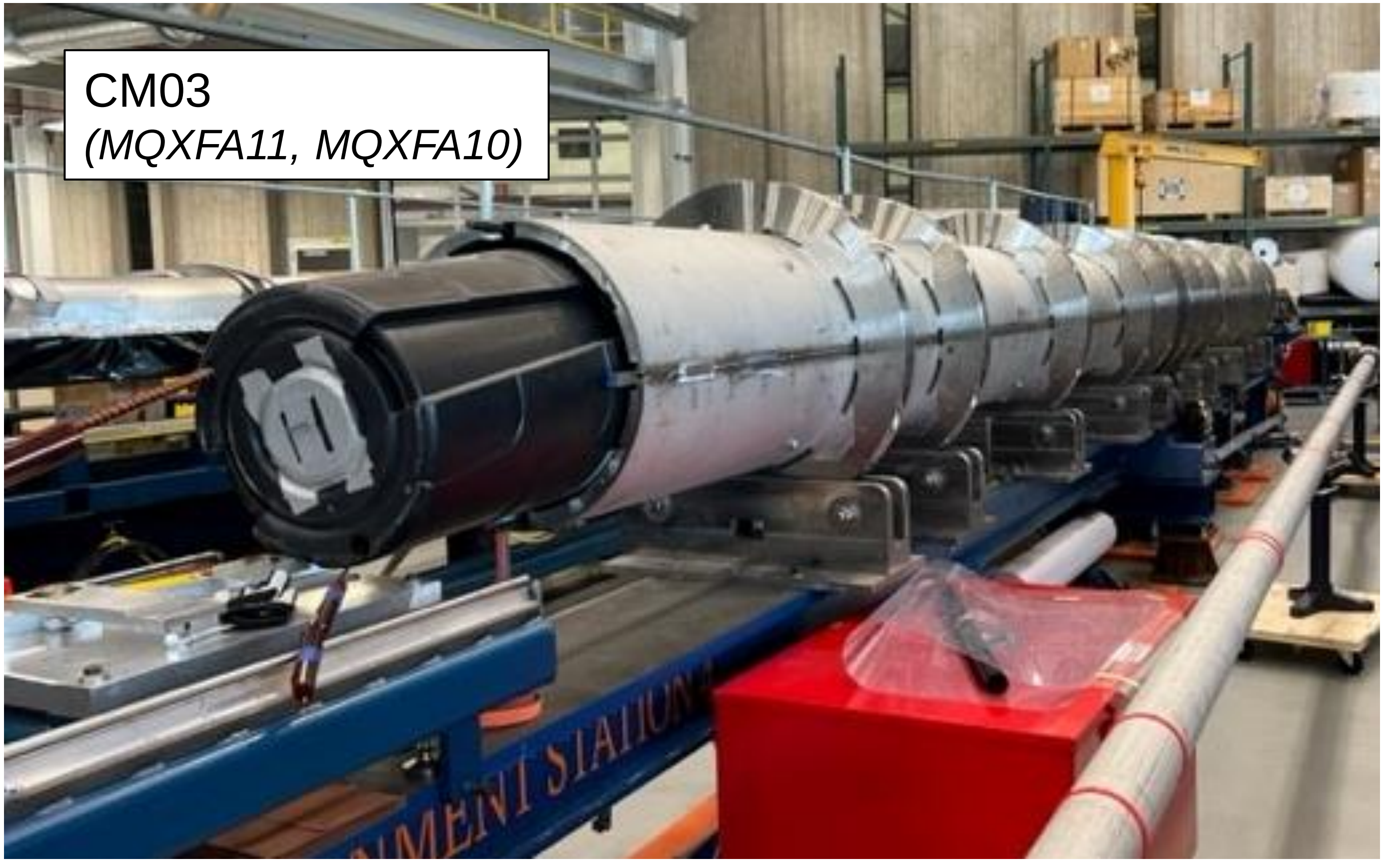
MQXFA06 Lead End: X= -0.367, Y= 0.246 mm
MQXFA06 Interface End: X= 0.367, Y= -0.246 mm
MQXFA05 Interface End: X= 0.070, Y= -1.308 mm
MQXFA05 Lead End: X= -0.070, Y= 1.308 mm



SSW_R_20230927_182200_AC_PitchYaw, SSW_R_20230927_183953_AC_PitchYaw

LMQXFA-03 Cold Mass Assembly

- LMQXFA-03 Ready for Shell Cutting post Longitudinal Welding



Longitudinal Welding Complete – Prep for Shell Trimming & End Cover Prep

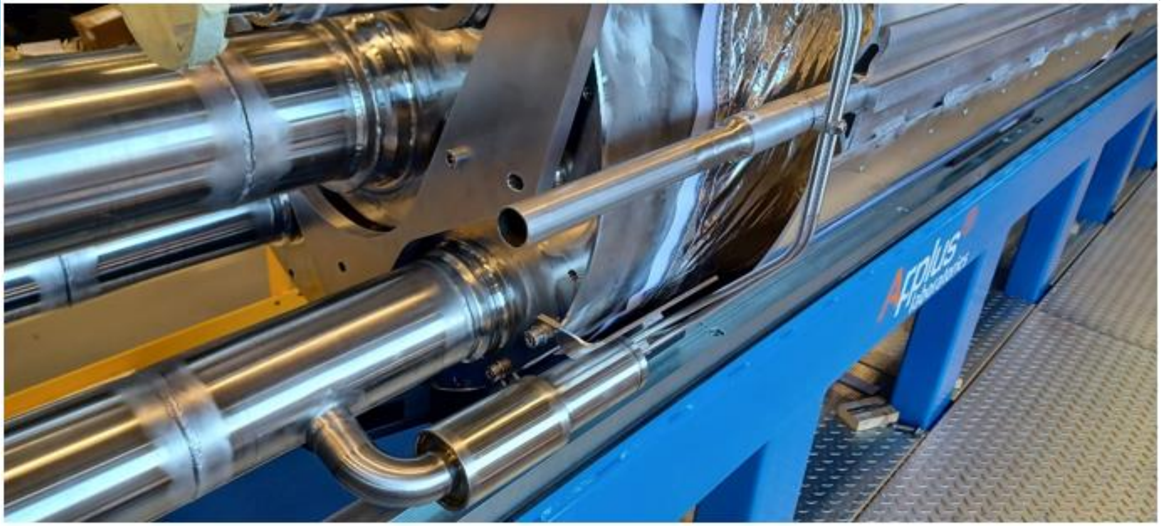
Cryo-Assembly Lesson Learned

- Once the CM02 is ready cryosting activity
- CA01 utilized CERN work instructions
- AUP developed their own traveler
  - CA01 was the first CA and several improvements of the procedure, and the execution of the work has been addressed
- Cryostat works as it has been designed
  - Successful cryogenic test
  - Heat loads measured during cold test was very close to the design calculations

Lesson learned

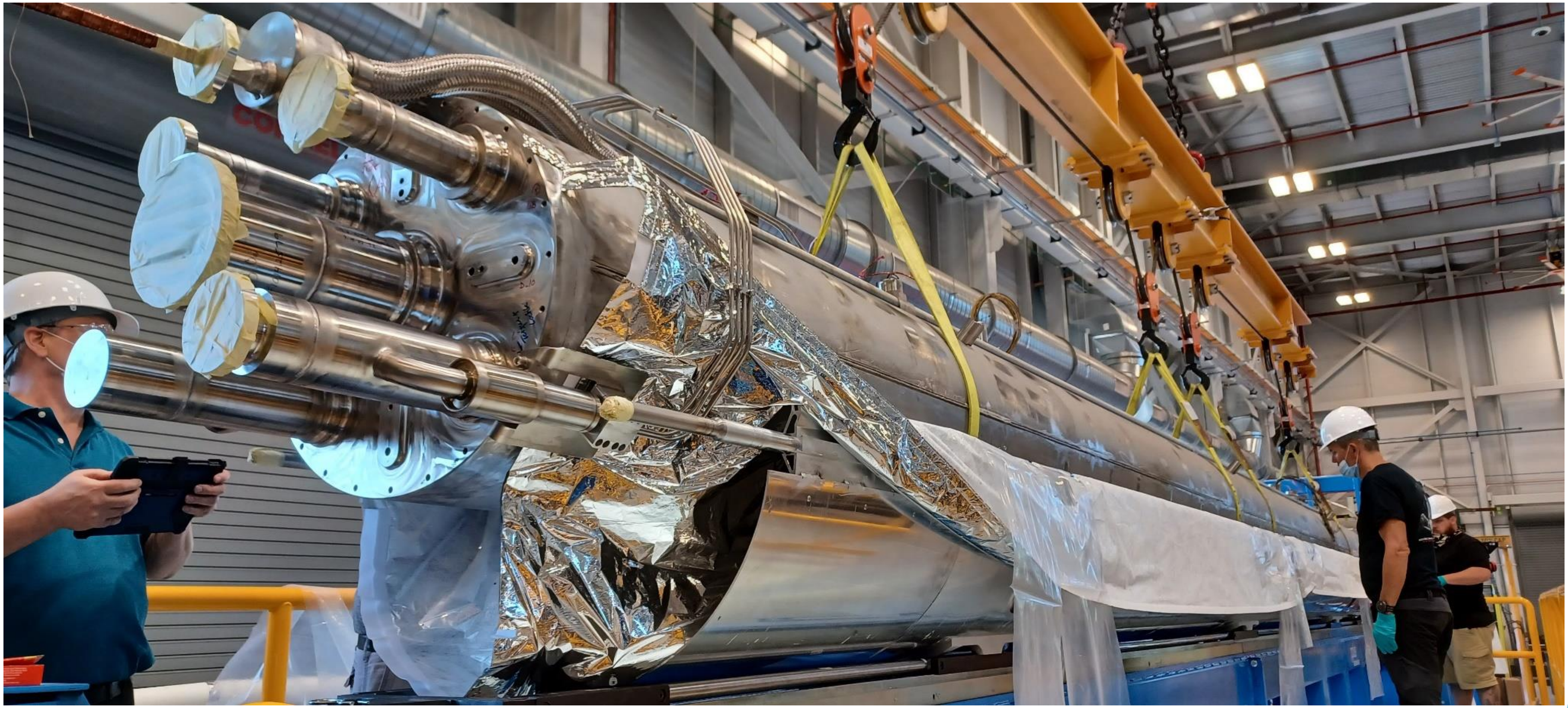
- MLI installation
  - Installation provision to prevent pinching of MLI when setting the Cold Mass.
  - Added MLI slits to Cold Mass blanket to prevent tearing in the event the parallel plate relief device opens.

Lesson learned



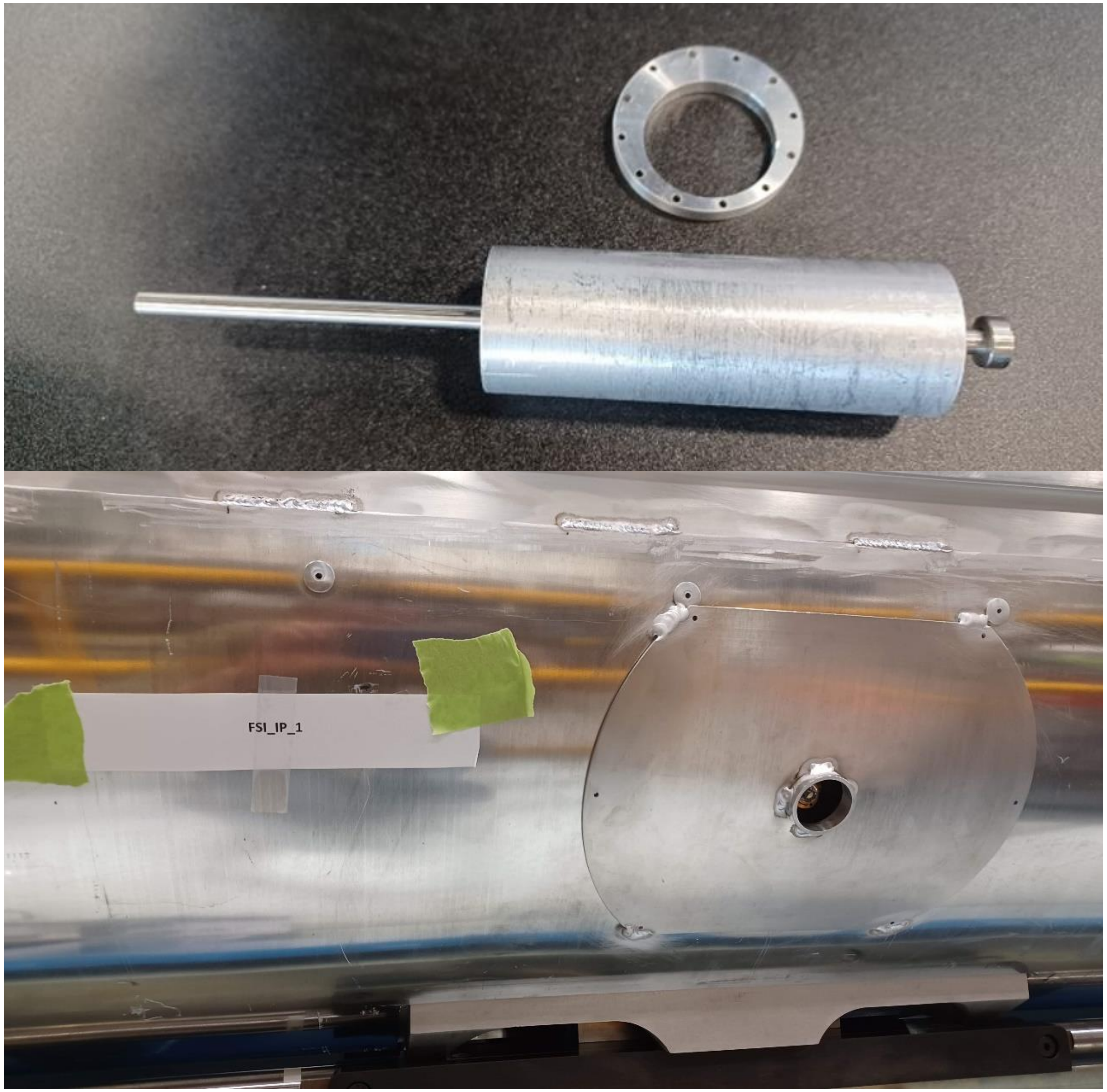
- Cryogenic piping
  - Adjust lengths for integration with the horizontal test stand

Lesson learned



- Removal and reattachment of one thermal shield cooling extrusion prior to placing the Cold Mass due to interference with the capillary systems.

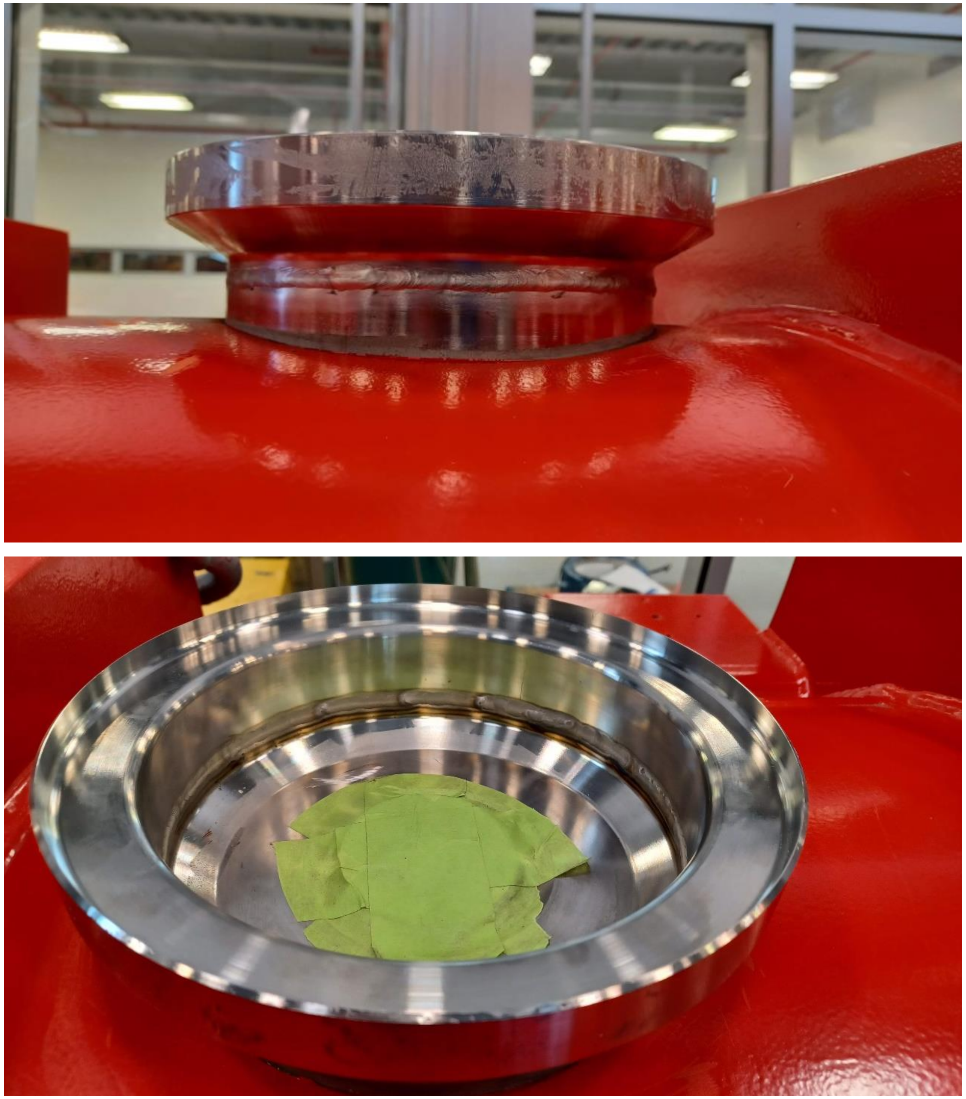
Lesson learned



FSI system

Tooling and optical survey method for locating the thermal shield covers.

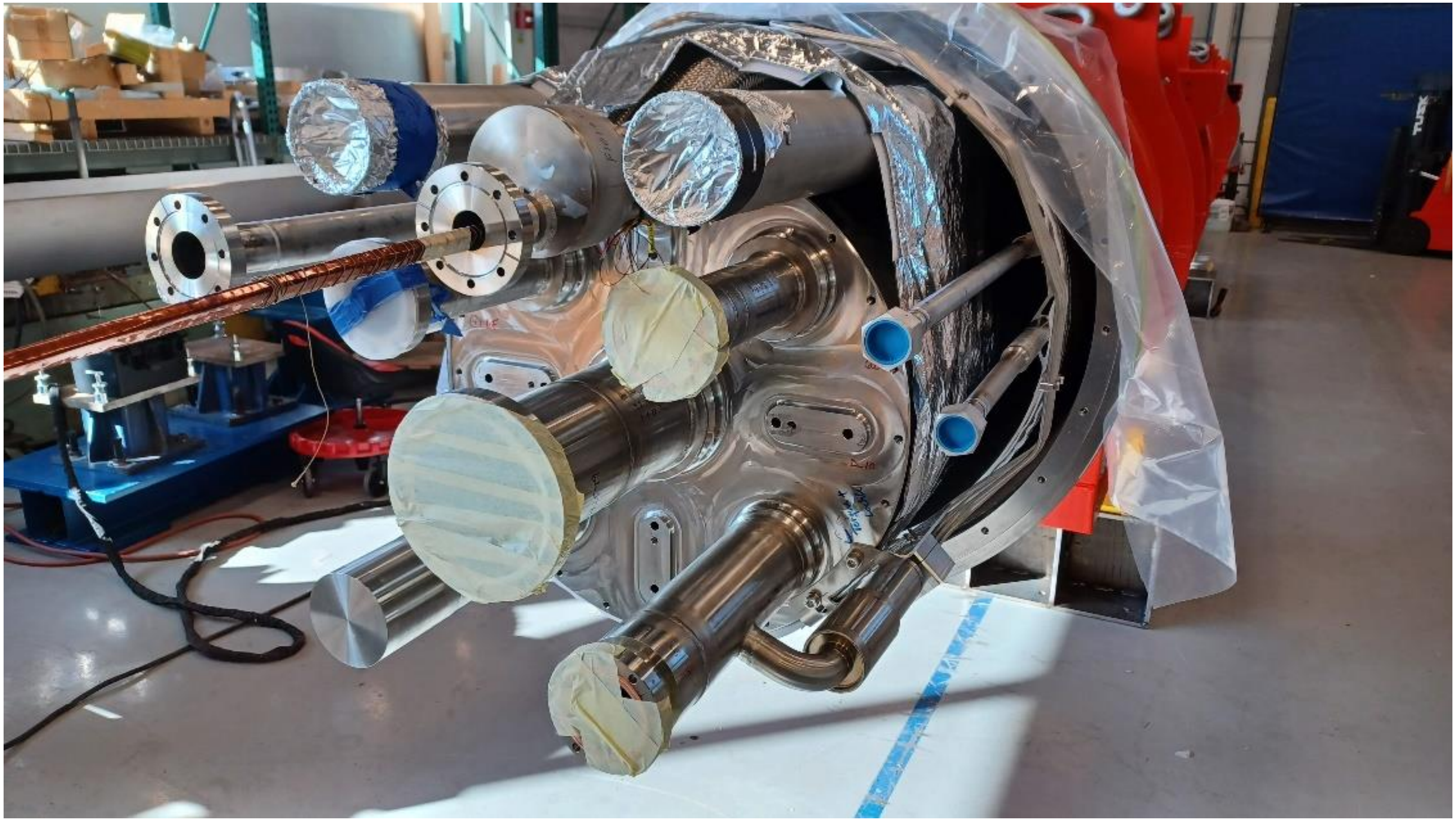
Lesson learned



- CLIQ/KMOD/IFS
  - Add weld preps on vacuum vessel flanges, IFS adapter rings, and CLIQ/KMOD/IFS cover flanges to improve weldability.

US HL-LHC AUP

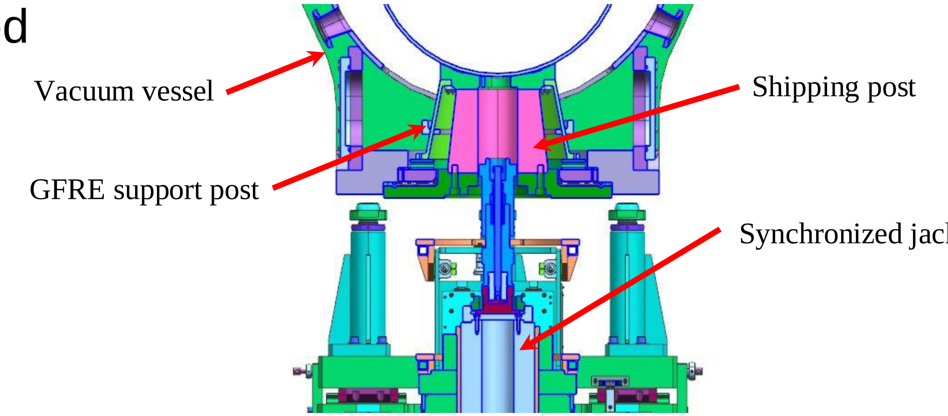
Lesson learned

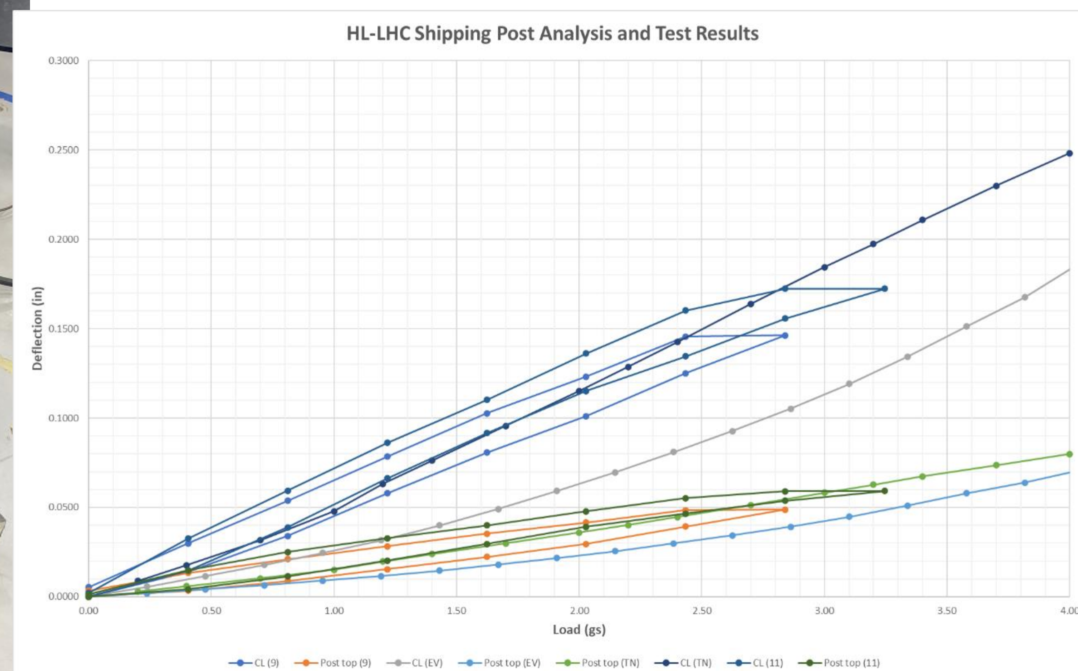


- Cryogenic piping
  - Check carefully interfaces; integration with the horizontal test stand.

Shipping Post

Shipping posts procurement completed
One of them was tested for deflection and compared with FEM analysis
Good agreement up to 3 g load

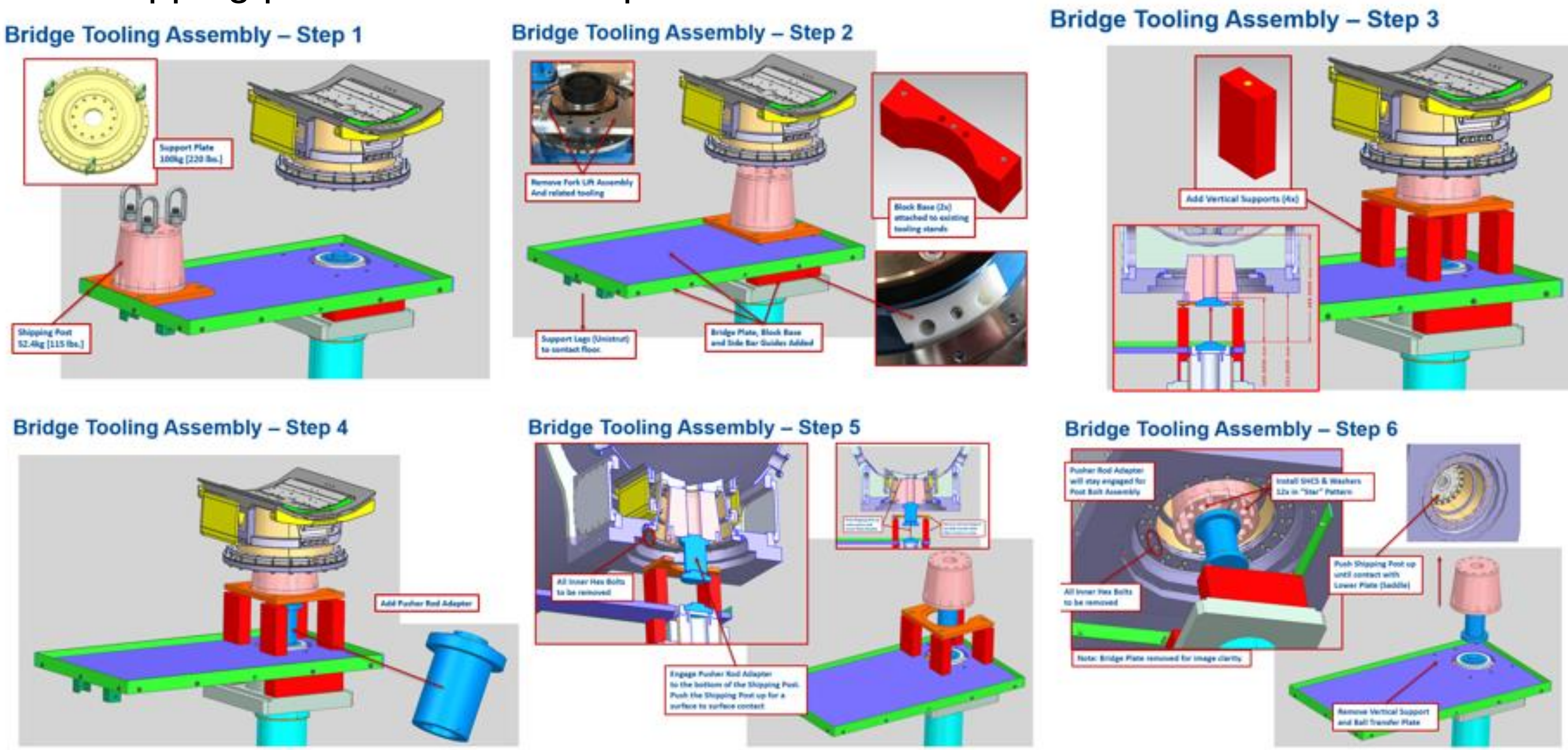




Shipping Post Tooling

- All the tooling are in house
- Installation procedure is close to completion

Shipping post installation steps



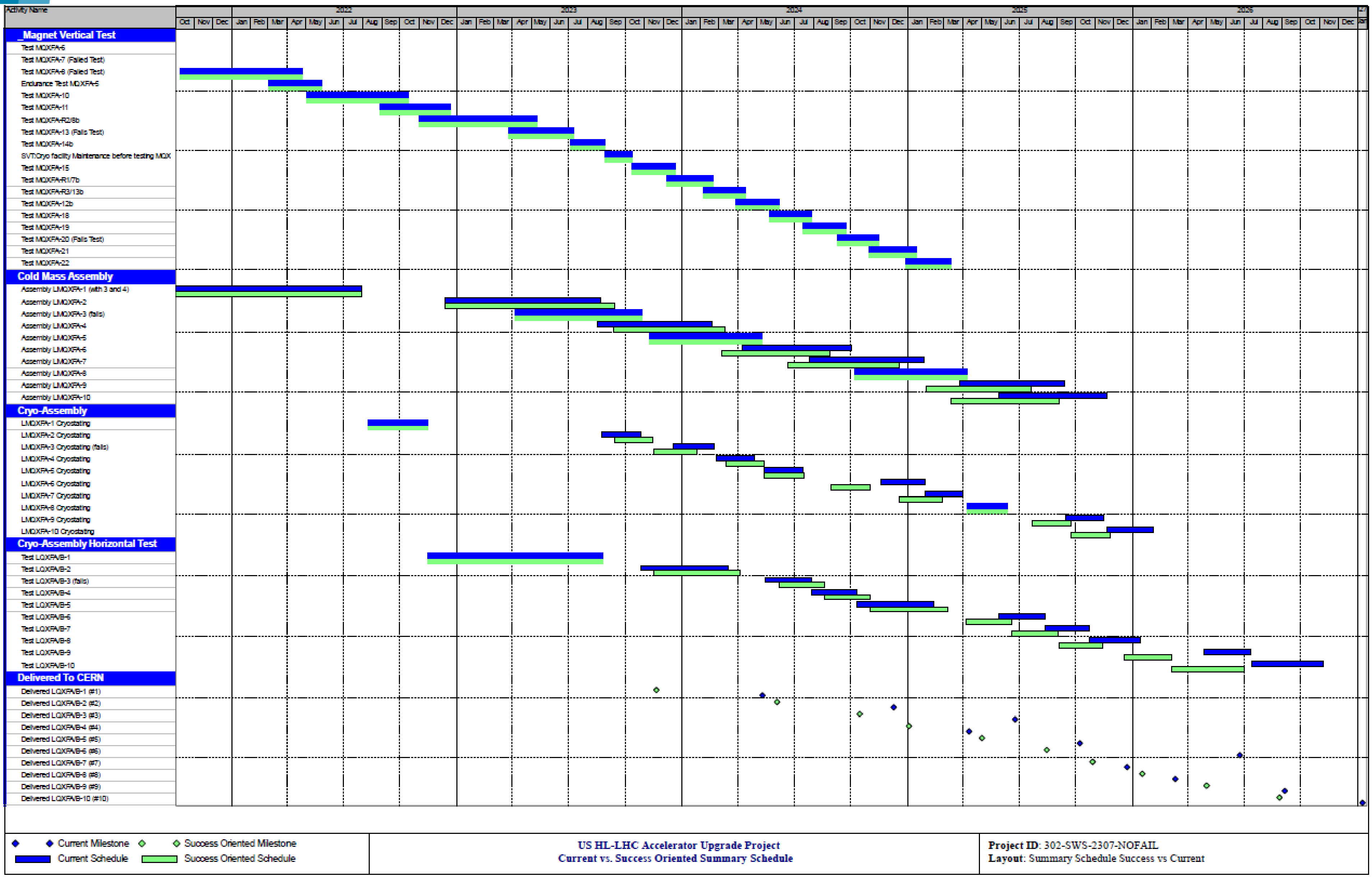
Schedule

Dates From July 2023 Working Schedule

Assembly Delivery Dates with Current Plan of 2 horizontal test failures

	Agreed Early Delivery Date	July 2023 working Schedule	Agreed Late Delivery Dates
Q1/Q3 Delivery 01	Nov-23	May-24	Oct-24
Q1/Q3 Delivery 02	Jun-24	Dec-24	May-25
Q1/Q3 Delivery 03	Aug-24	Apr-25	Jul-25
Q1/Q3 Delivery 04	Nov-24	Jun-25	Oct-25
Q1/Q3 Delivery 05	Mar-25	Oct-25	Feb-26
Q1/Q3 Delivery 06	Jun-25	Dec-25	May-26
Q1/Q3 Delivery 07	Aug-25	Mar-26	Jul-26
Q1/Q3 Delivery 08	Nov-25	Jun-26	Oct-26
Q1/Q3 Delivery 09	Apr-26	Sep-26	Mar-27
Q1/Q3 Delivery 10	Aug-26	Jan-27	Jul-27

Success oriented schedule



Conclusions

- CA01 has been completed and being prepared for shipment to CERN (acceptance formalities are underway)
- CM02 weld is complete and passed PAUT NDT tests. Next is to weld the saddles
- CM03 longitudinal weld has been completed and it is being prepared for cutting the shells
- New AUP traveler for CA activities has been prepared
- Shipping post and the shipping post installation tools were procured, and shipping post installation procedure is close to completion