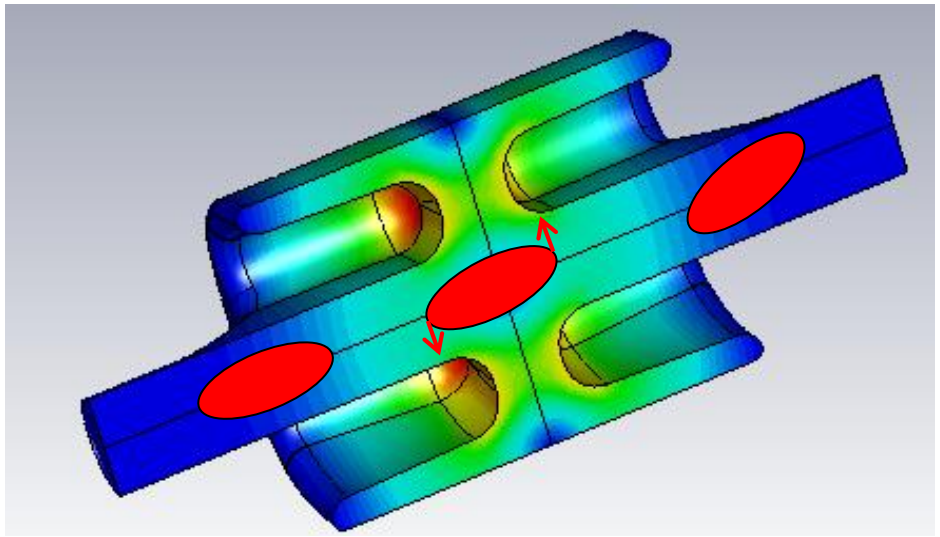
RFD pre-series cryomodule status and DQW series planning

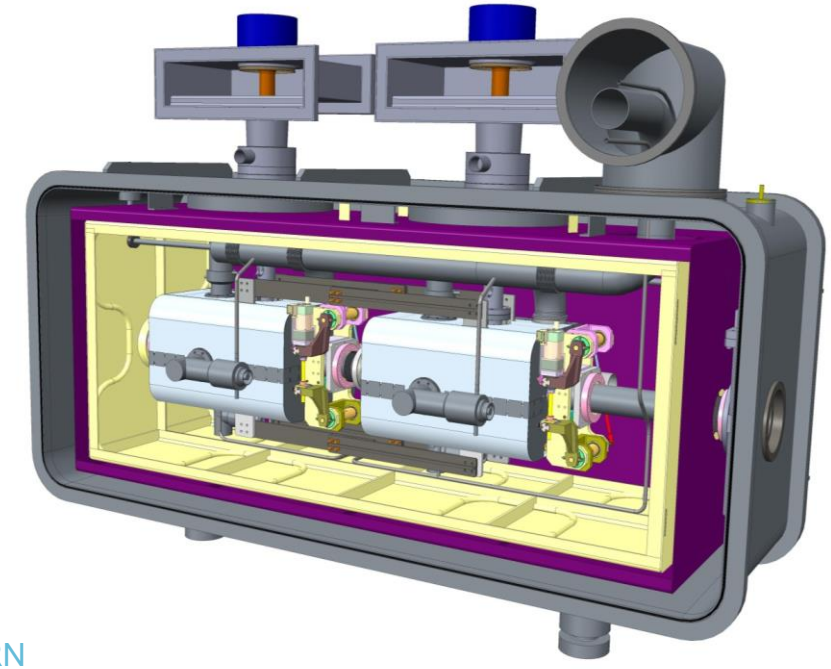
Thomas Jones on behalf of the UK-CERN Team

11th HL-LHC Collaboration Meeting, October 19th 2021

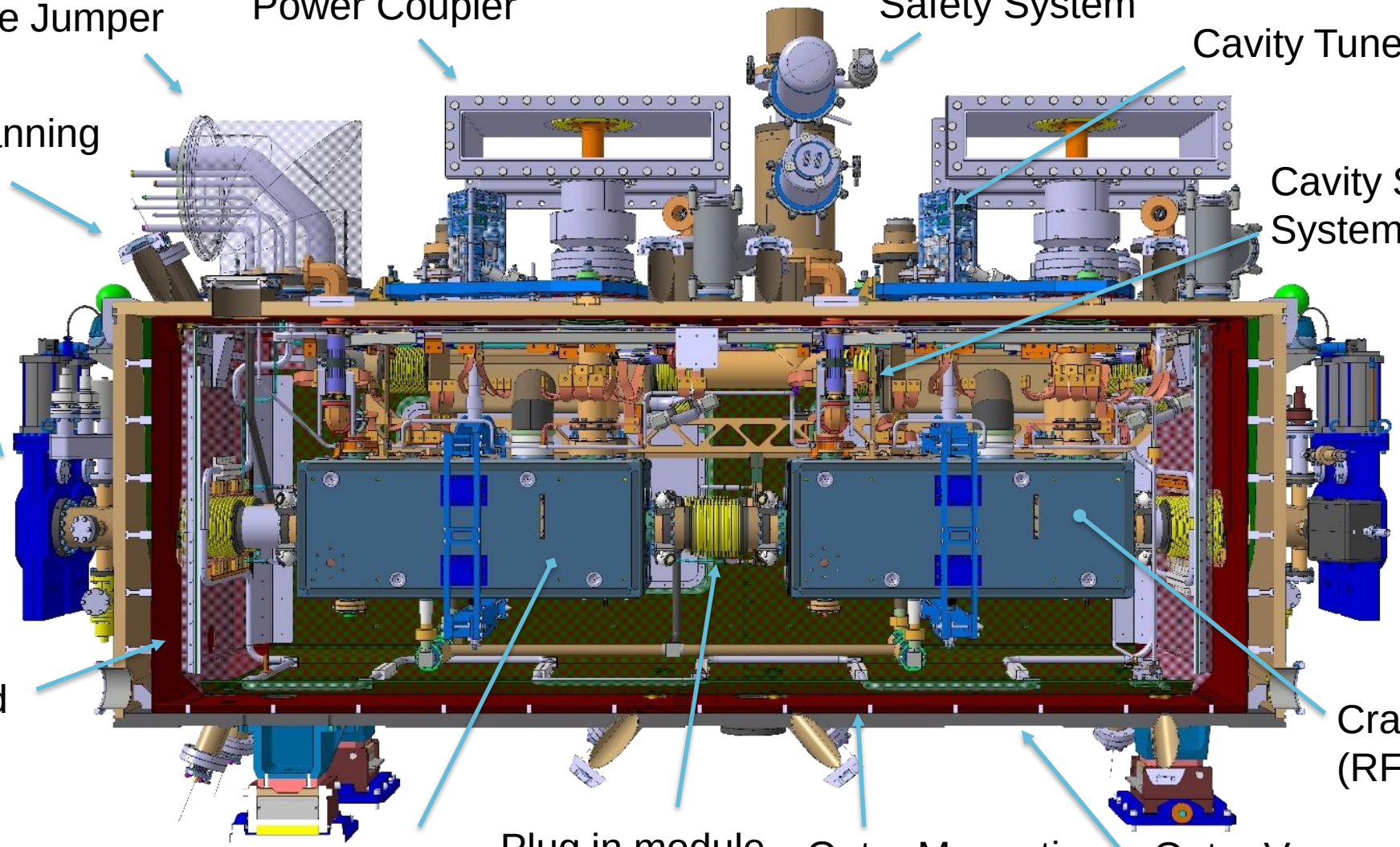
Background to UK involvement in Crab Cavities

- Lancaster University Involvement since 2009 with the 4ROD Crab Cavity concept.
- STFC Daresbury Lab involvement since 2012, including the initial Cryomodule design work.
- Worked closely with CERN for the development, build and world first testing of the DQW Cryomodule.
- Currently completing Phase 1 of the UK project which is the build of an LHC compatible Pre-Series unit based on using the RFD Crab Cavity.
- Funding started 1st April 2020 for Phase 2 which is for providing 4 Series Cryomodules using DQW Cavities for HL-LHC.

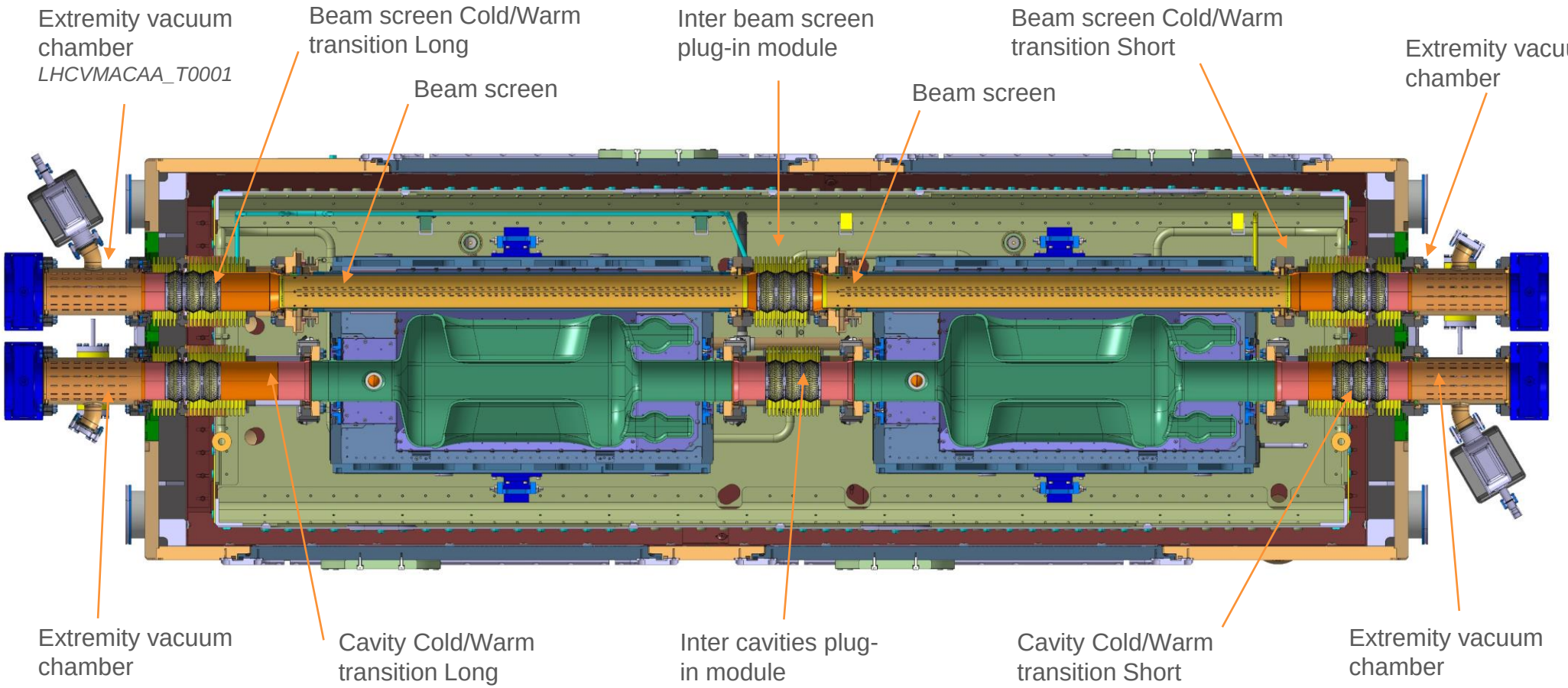




RFD Pre-Series Crab Cavity Cryomodule



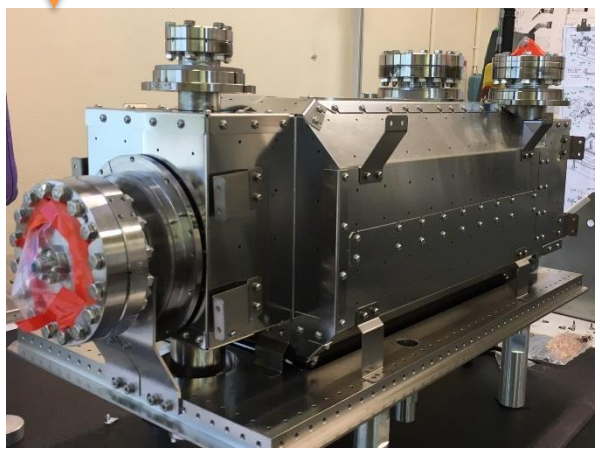
Beam section of RFD Cryomodule

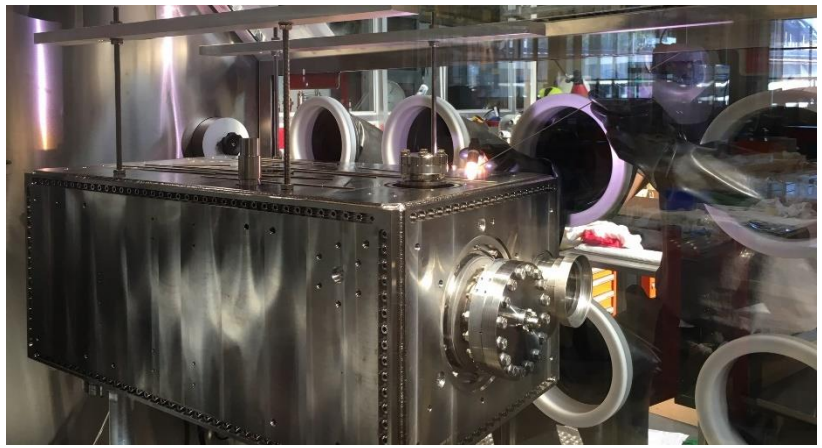


CAD Images from Teddy Capelli. His talk is tomorrow at 16:45 and has more details.

RFD Pre-Series Dressed Cavity production

- Cold magnetic shields from UK-collaboration
- He-tank assembly very efficient (~1.5 mons) after the experience from DQW
- Frequency shift during He-tank assembly $\sim \pm 15$ kHz (negligible)
- Both Cavities have been successfully tested at cold with HOMs





Outer Vacuum Vessel

RFD outer vessel :

- Large gaskets removed for LHC compatibility
- Overall dimensions : 2800x950x1300
- Mass : 3100kg
- St. Steel welded assembly
- Brackets take the Top Plate mechanical loads

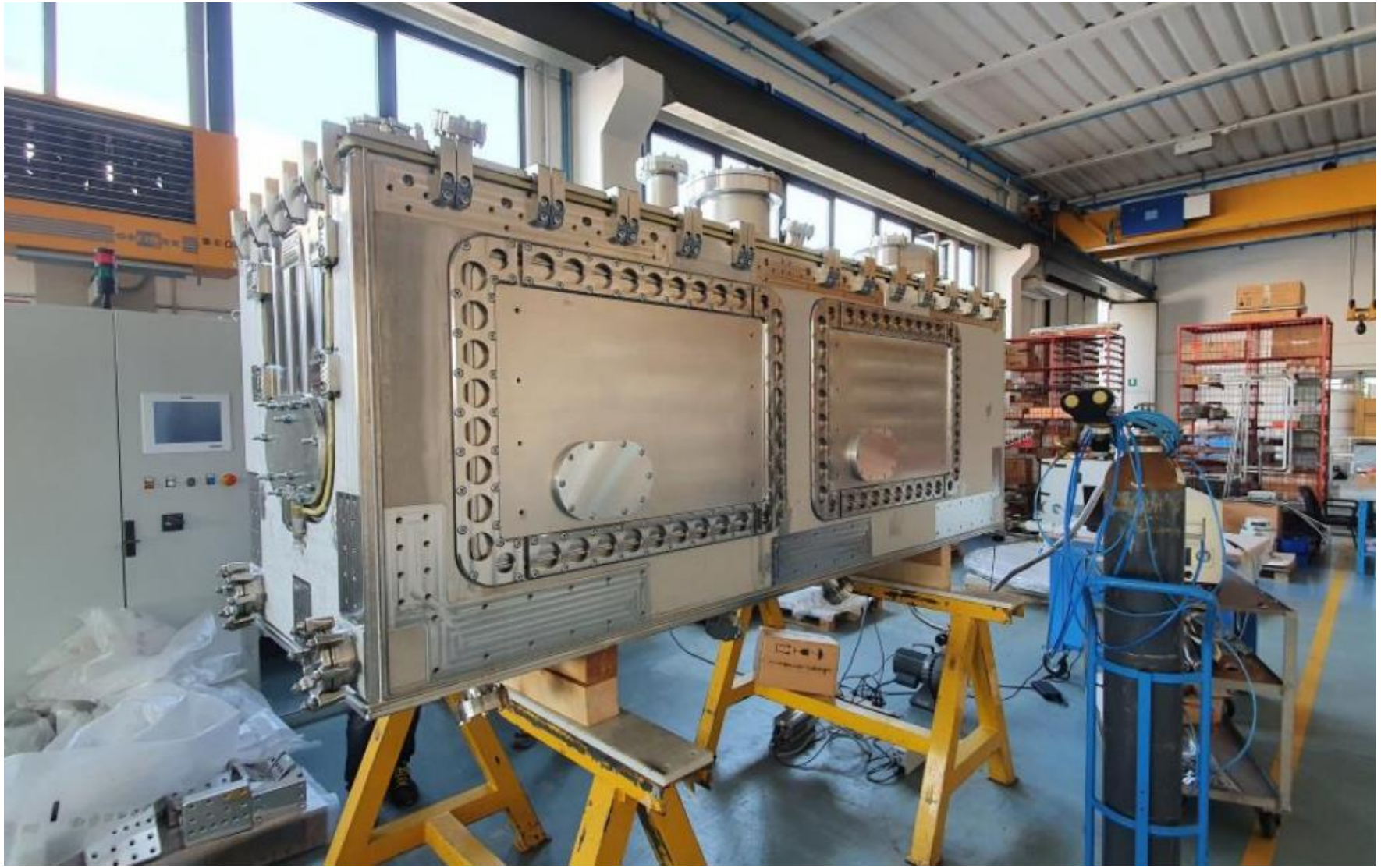
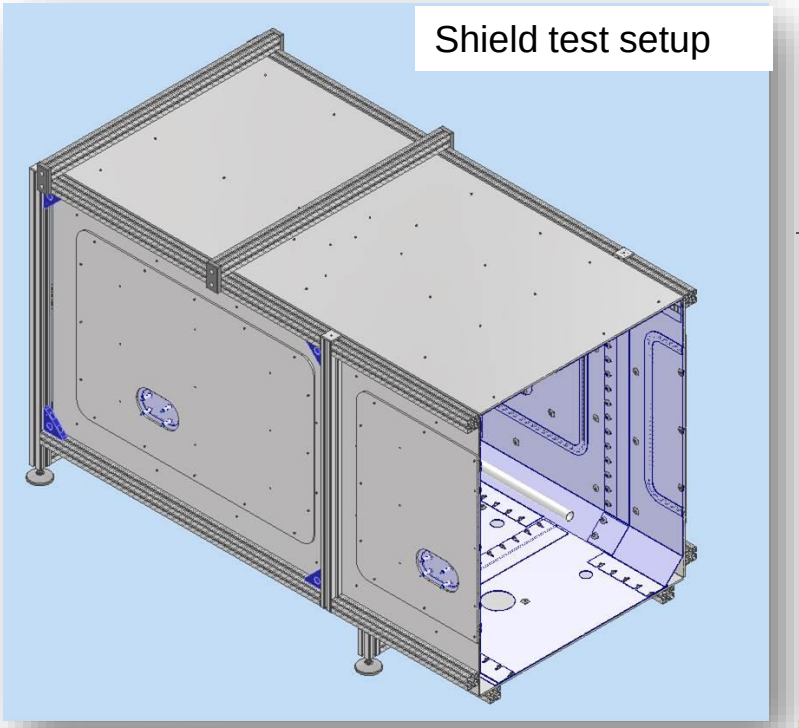
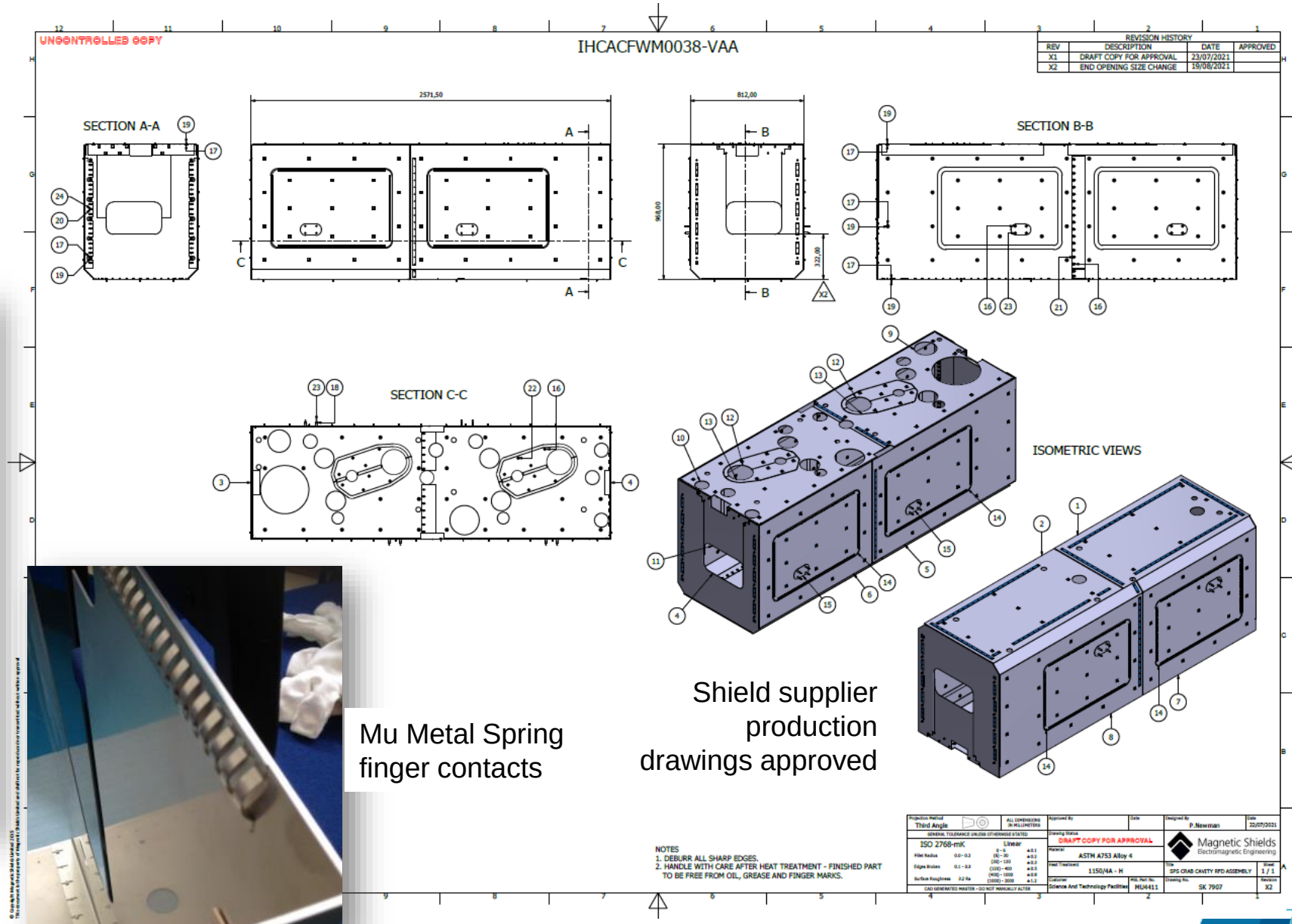


Image courtesy J.Sauza Bedolla - Lancaster

Warm Magnetic Shield

- DQW design adapted to RFD
- Forms a “Second Skin” to the Outer Vacuum Chamber
- Material : MuMetal Th.:2mm
- Currently in production in the UK





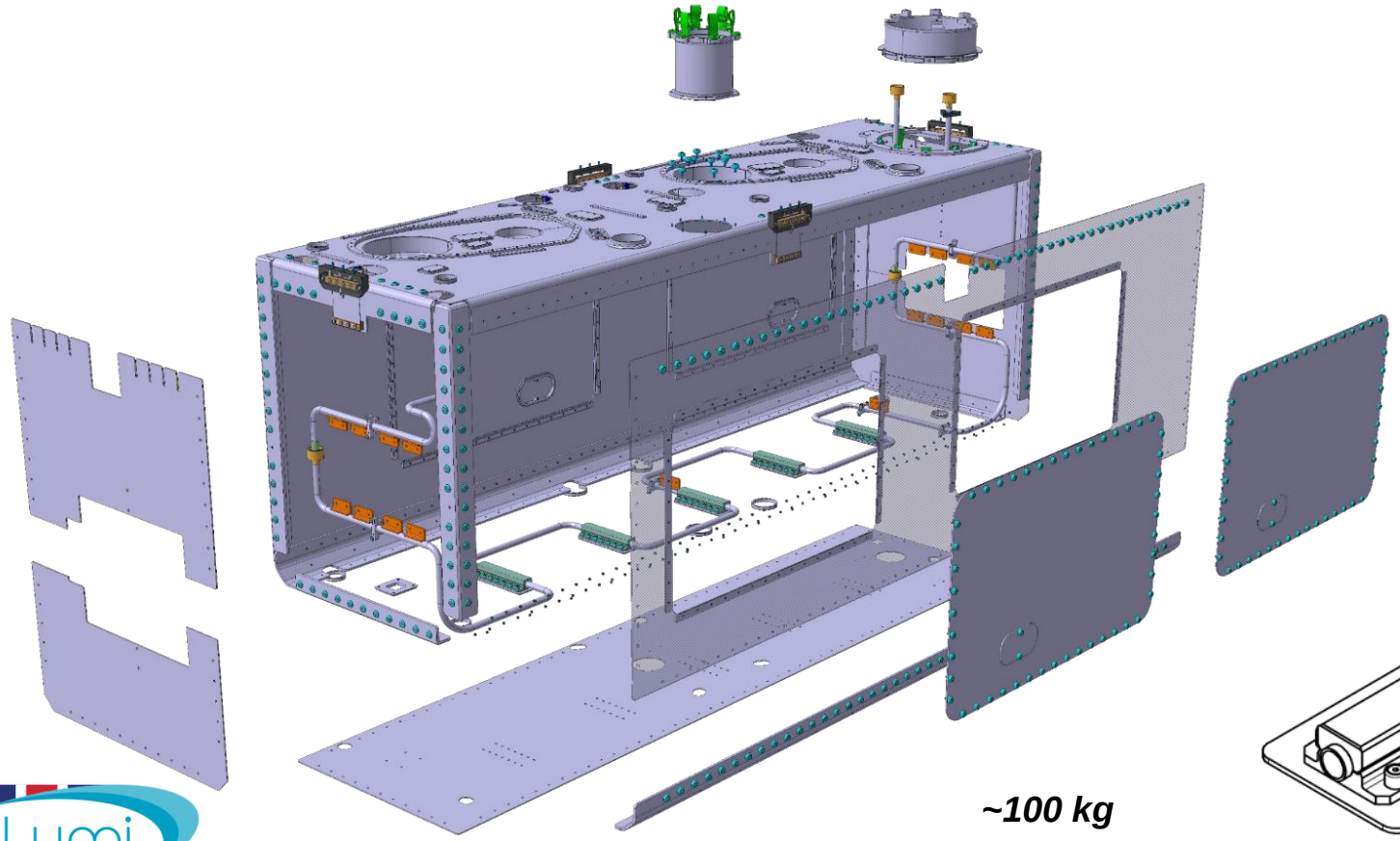
Mu Metal Spring finger contacts

Shield supplier production drawings approved

Thermal screen

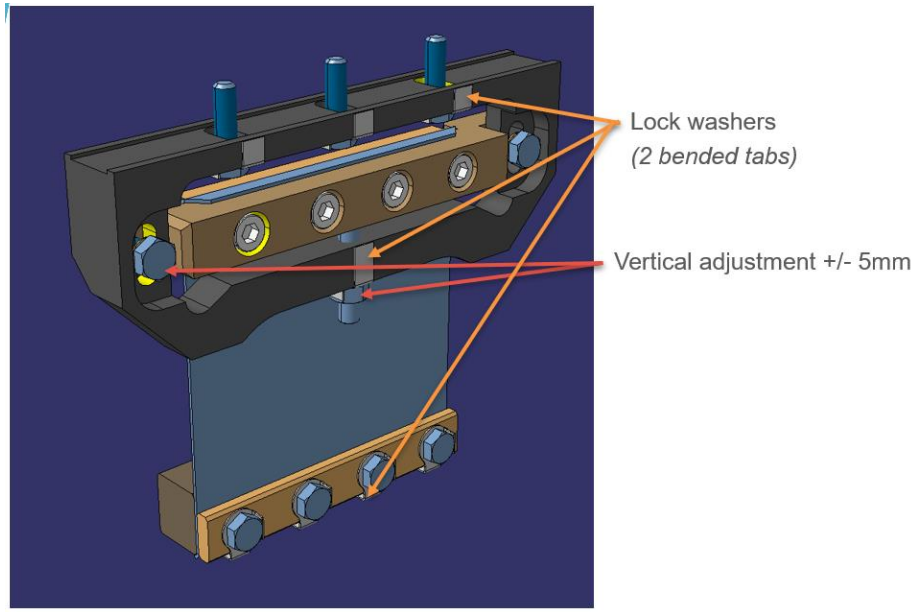
Design changes from DQW:

- Copper changed to 3mm thick 6061 T6 Aluminium Alloy plates
- Significant cost and weight saving
- Stainless Steel 316L Cooling circuit
- Adjustable flexure support system

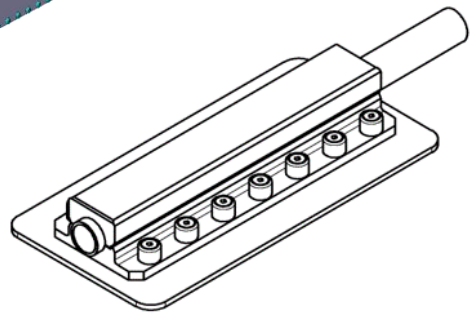


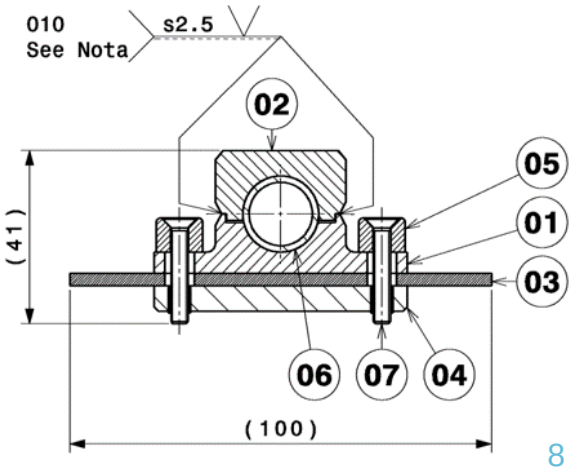
~100 kg

Support Flexure



Cooling circuit connection





Touch Screen Installed in Design Office

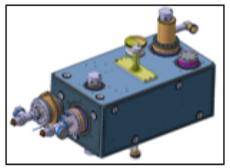
Collaborative procedure development, design review and drawing checks whilst socially distant ✓

Logistics planning

Item Traveller: HCACFDC004
RFD Dressed Cavity Prototype CERN

EDMS xxxxxxx.V1

READ THIS COMPLETE INFORMATION BEFORE ANY INTERVENTION



(3D: EDMS 2322480 V.3)

WARNINGS	
Equipment prepared for clean room	
Handle with clean gloves	
Pressurized with nitrogen	
Fragile, handle with care.	
Specific handling procedures	

1. Identification of ITEM

1.1 – Equipment Designation : RFD dressed cavity Prototype CERN

1.2 – MTF Equipment Identifier : HCACFDC004-CR000002

1.3 – CERN Drawing ref : **LHCACFDC0002 / LHCACFDC0003**

1.4 – Daresbury Laboratory Storage Location : ETC survey room and assembly Cleanroom

1.5 – CERN Contacts :

- Nuria Valverde Alonso: +41754113831 / nuria.valverde.alonso@cern.ch
- Marco Garlasche: +41754117489 / marco.garlasche@cern.ch

1.6 – STFC-UK Contacts :

- Thomas Jones: +447749505558 / thomas.jones@stfc.ac.uk
- Carlos Granjeiro: +447400675563 / carlos.granjeiro@stfc.ac.uk

2.ITEM Specifications

EDMS 1389669: Engineering Specification for the dressed bulk niobium Crab Cavities

- **Verification requirements of the Dressed Cavities** : Section 14.5
- **Packing And Shipping** : Section 18

EDMS 2058183: Guidelines for Compliance with CERN Safety Requirements

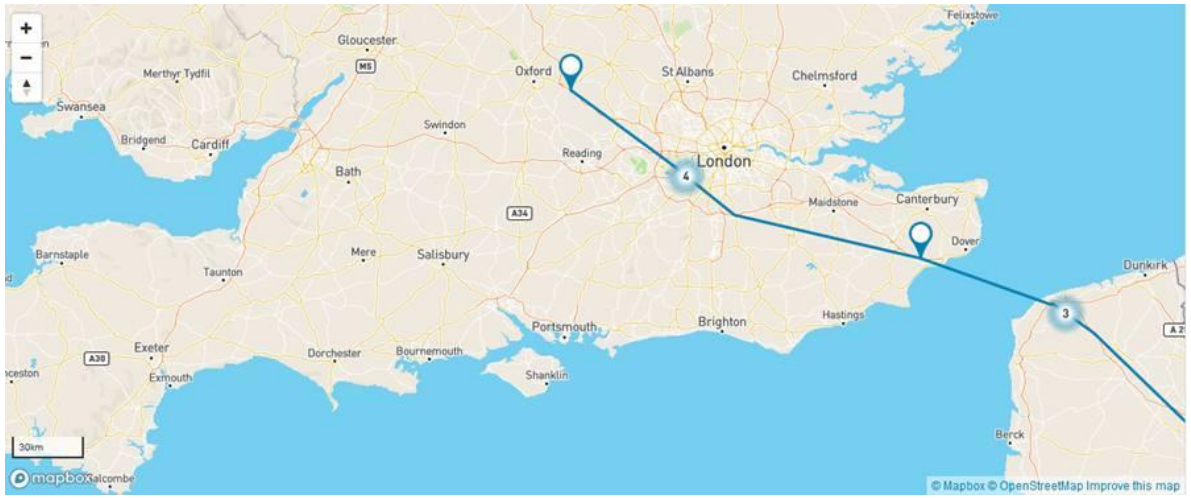
- Compliance with **CERN safety GSI-M4** : Section 11 Annex C
- Compliance with **CERN safety PED and Vacuum** : Section 11 Annex C

EDMS 2043014: Engineering Specifications - Cryomodules for Crab cavities.

- **Safety requirements** for tools and assembly procedures: section 4.9.2
- **Vacuum:** Section 7.7, Specific requirements for vacuum components

- Development of travellers including outgoing and incoming inspection procedures for all equipment
- Using Assembly Building 3D model in planning assembly and storage.
- Considerable amount of work to ensure a trouble free transport of goods from CERN to the UK post Brexit.

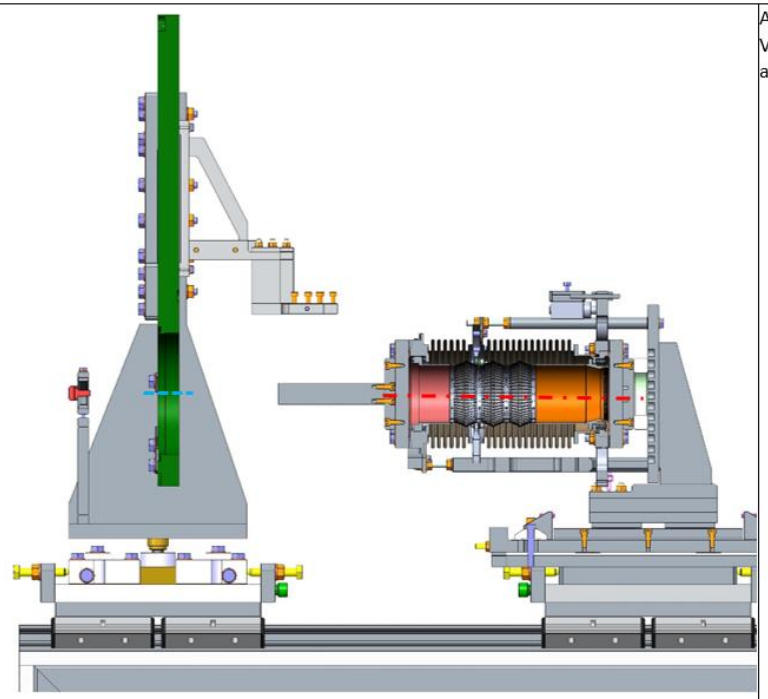
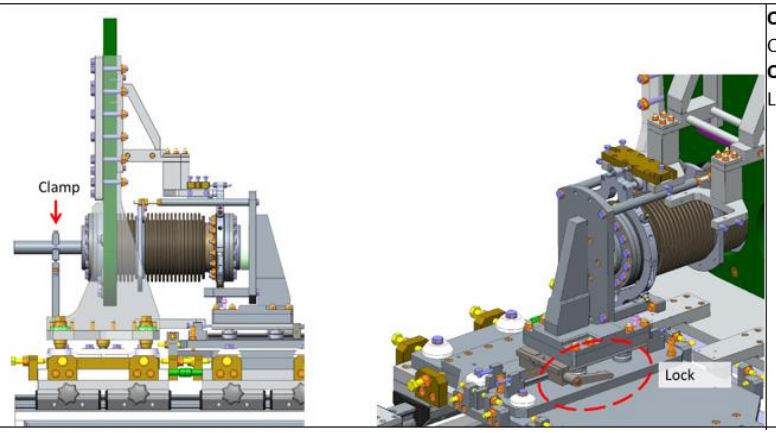
RFD2 Cavity and Ancillaries arrived at Daresbury



- Arrived 29th September 2021. Careful prior planning led to a trouble free transport ✓
- RF Acceptance Testing of the Cavity taking place now

Pre-Cleanroom Assembly Procedure

- Pre-Cleanroom Assembly Procedure Approved
- Cleanroom Assembly Procedure made good progress.
- Tooling for first steps is on site.

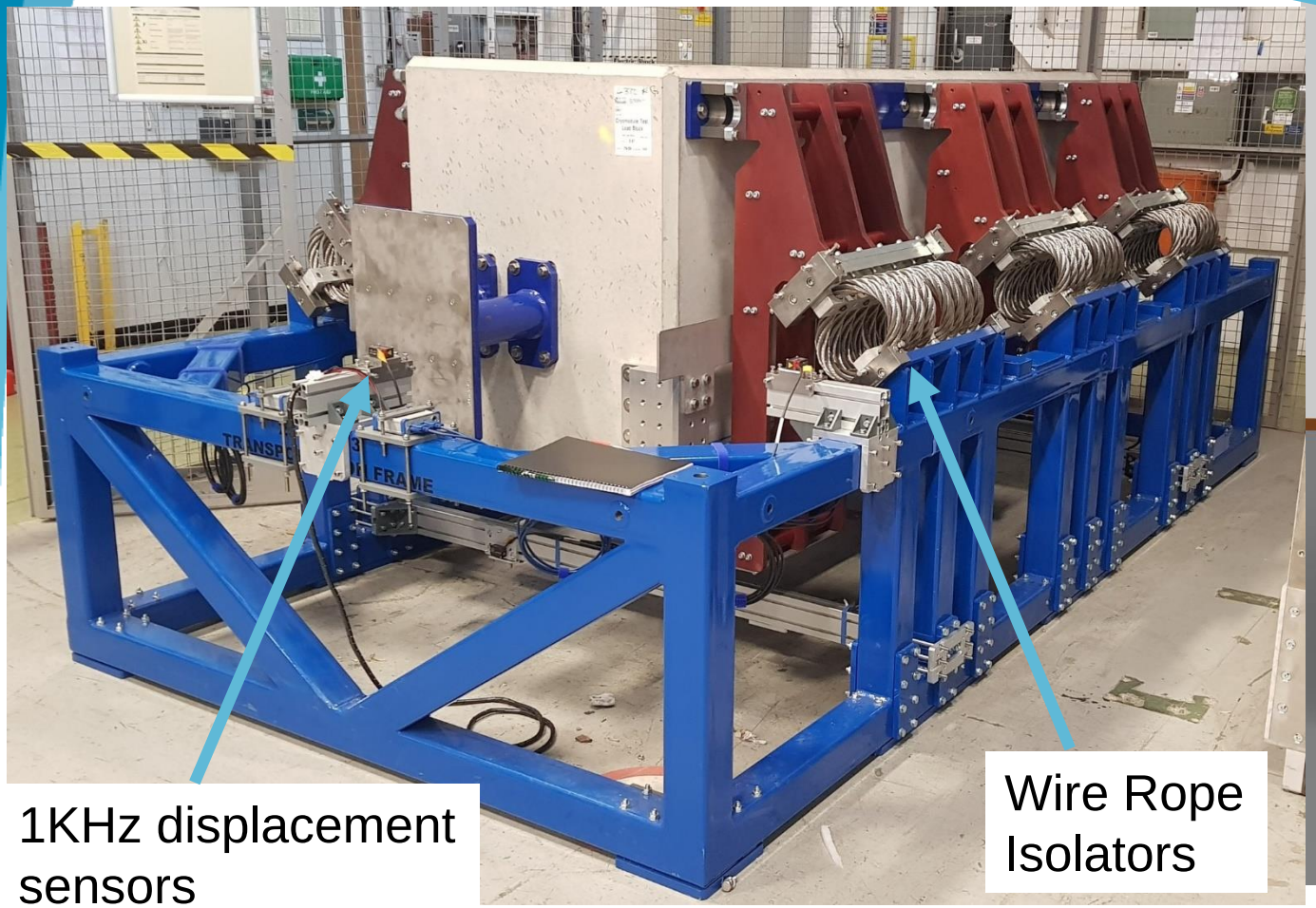
2.7.		Align CWT axis to Valve plate/beam axis	**Dimensional Check** Axes Co-incident to <0.1mm
2.17.		**Operator 1** Clamp rod **Operator 2** Lock slideway	

Cavity String assembly Lifter

- Movement qualified with the laser tracker
- <1mm lateral movement over the full stroke ✓

Transport Frame and Drop Test Kit all on site

Lifting gantry



1KHz displacement sensors

Wire Rope Isolators

- Practise assembly of the transport frame ✓
- Testing taking place over the next couple of weeks

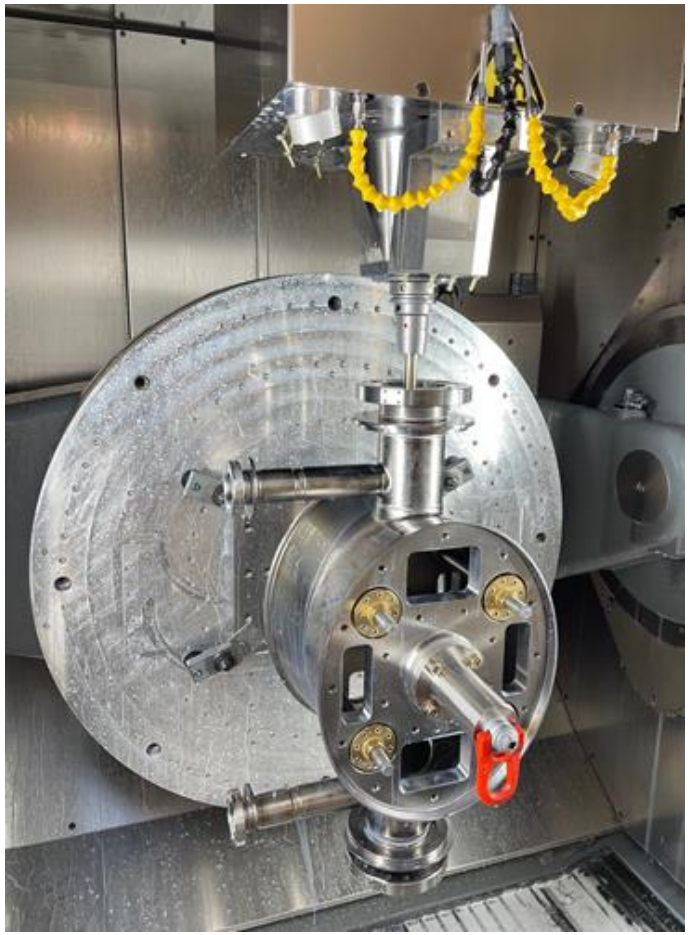
RFD Pre-Series Planning updates

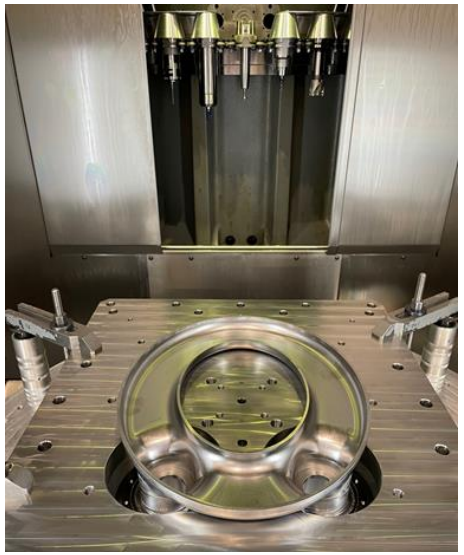
- RFD1 is due to be shipped end of October.
- Procurement of long lead items is progressing;
  - OVC passed acceptance tests and is ready to be shipped to DL.
  - Magnetic shield, drawings complete, order placed, materials ordered, Manufacturing started.
  - Cryolines, supplier selected, some iteration on the design as per supplier requests, launch of manufacture soon.
  - Cavity Support System manufacturing started
- Plan to have pre-cleanroom assembly and cleaning complete before Xmas break.
- ISO4 assembly will then begin after the Xmas break, for a CM assembly complete date in September 2022.

DQW Cryomodule Production updates

- Funding is secured from STFC of £4.9million to build 4 modules, within the HL-LHC-UK2 project which runs to end of March 2025.
- CERN will contribute with significant in-kind contributions, additional funding (£1.4million) and staff effort.
- Modules will be using DQW cavities (with the North American Collaboration providing Series RFD).
- Design work has started at CERN for DQW series Cryomodule.
- Cavities are in production, with Pre-Series at CERN and Series at RI.
- First Series Cavities are due at Daresbury in January 2023.

DQW Pre-Series @ CERN





- First bare cavity expected **Dec. 2021**, +1 month for 2nd cavity
- Jacketing components (helium tank) on-track

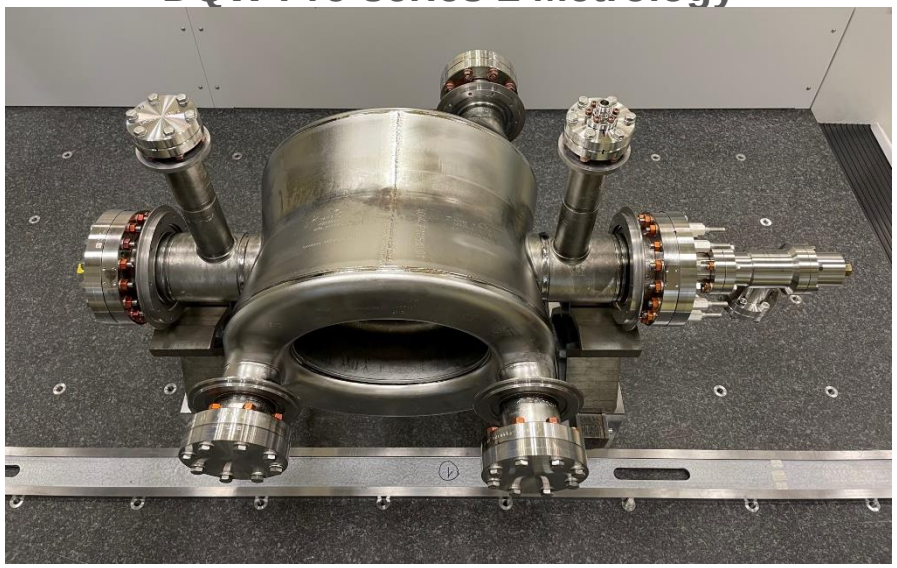
Talk on Thu@14:30

Manufacturing of RFD prototypes & DQW series
Simon Barrière

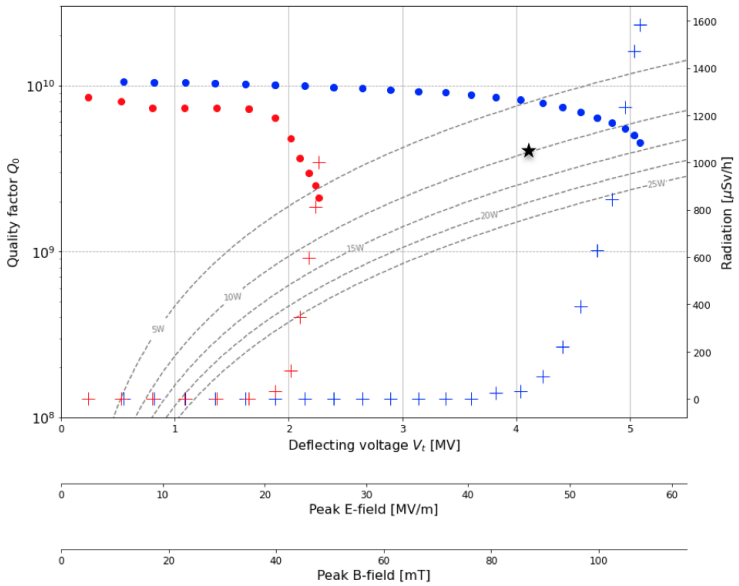
DQW Pre-Series @ RI

DQW Pre-series 1 HPR Preparation

DQW Pre-series 2 Metrology



- Pre-series bare cavity 1:
  - Metrology done.
  - HPR and Ready for re-CT, week 43/44.
- Pre-series bare cavity 2:
  - CT successful.
  - Currently in metrology.

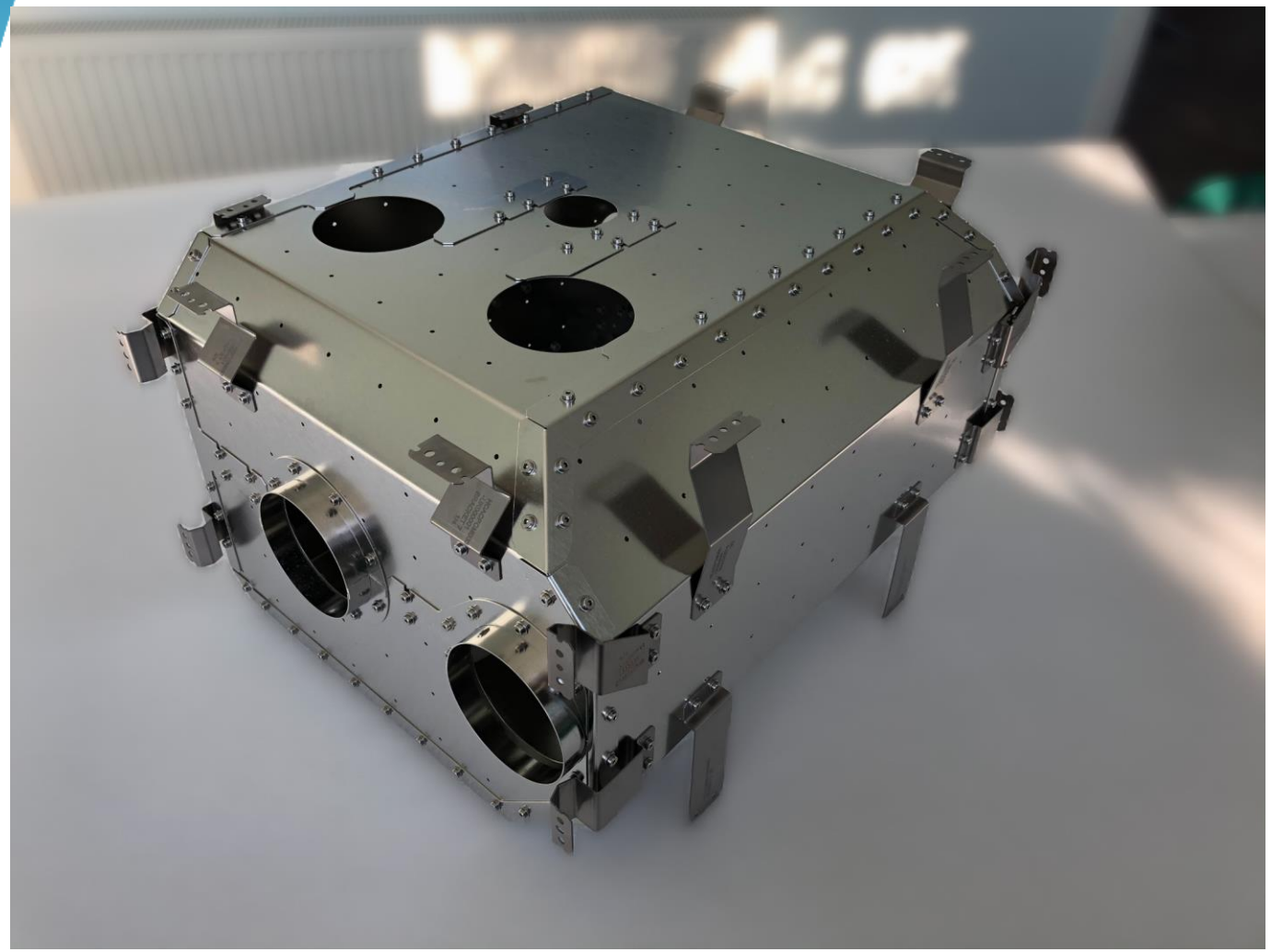


Cold Test @CERN

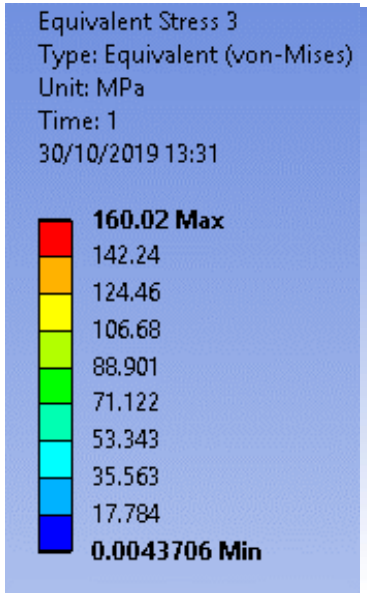
Talk on Thu@14:45

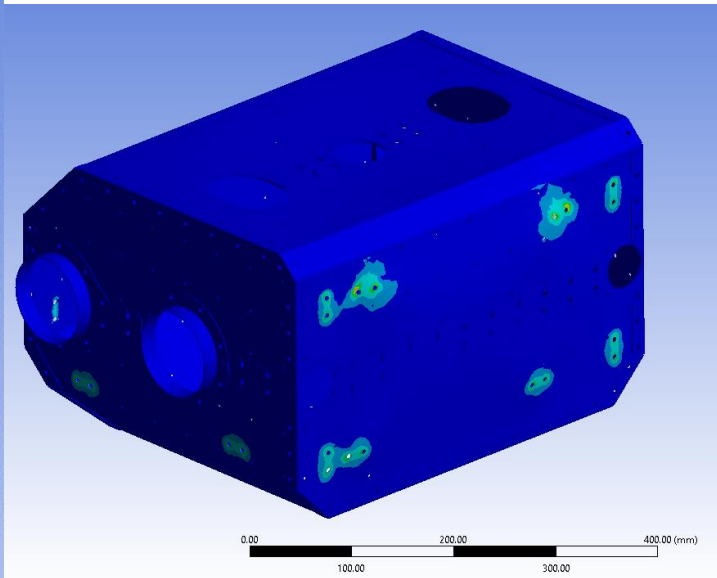
Industrial DQW pre-series status	*Alejandro Castilla Loeza*
	14:45 - 15:00

DQW Series Cold Magnetic Shield

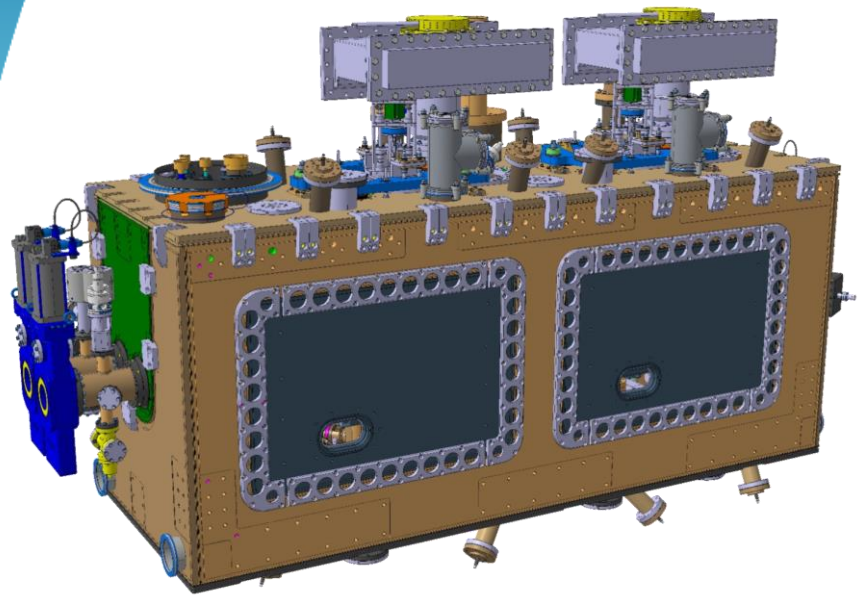


- DQW Production Cold Magnetic Shield
- **First hardware delivered for HL-LHC-UK Phase 2**
- Designed by STFC/Lancaster Uni.
- Manufactured in UK Industry.

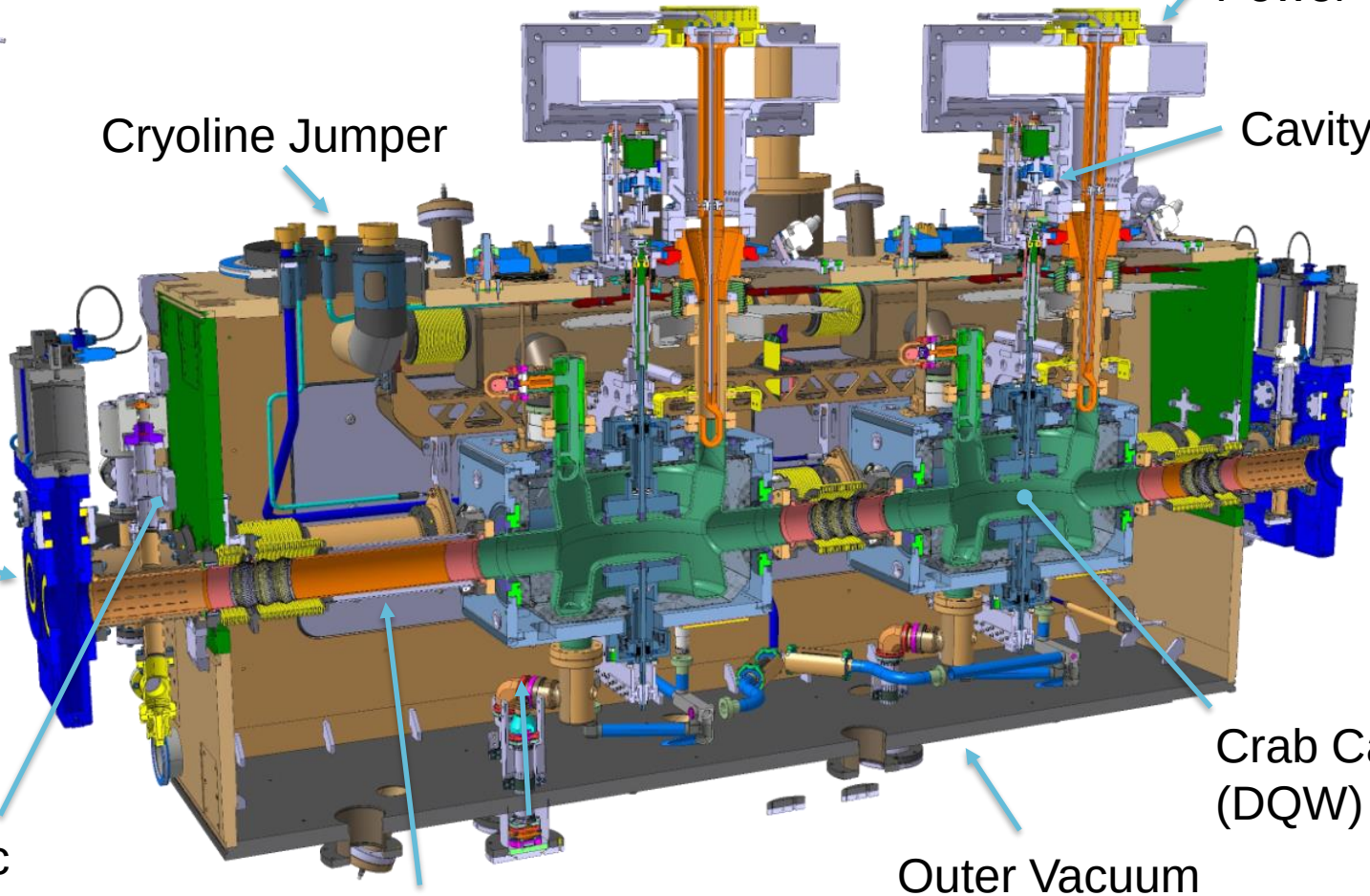




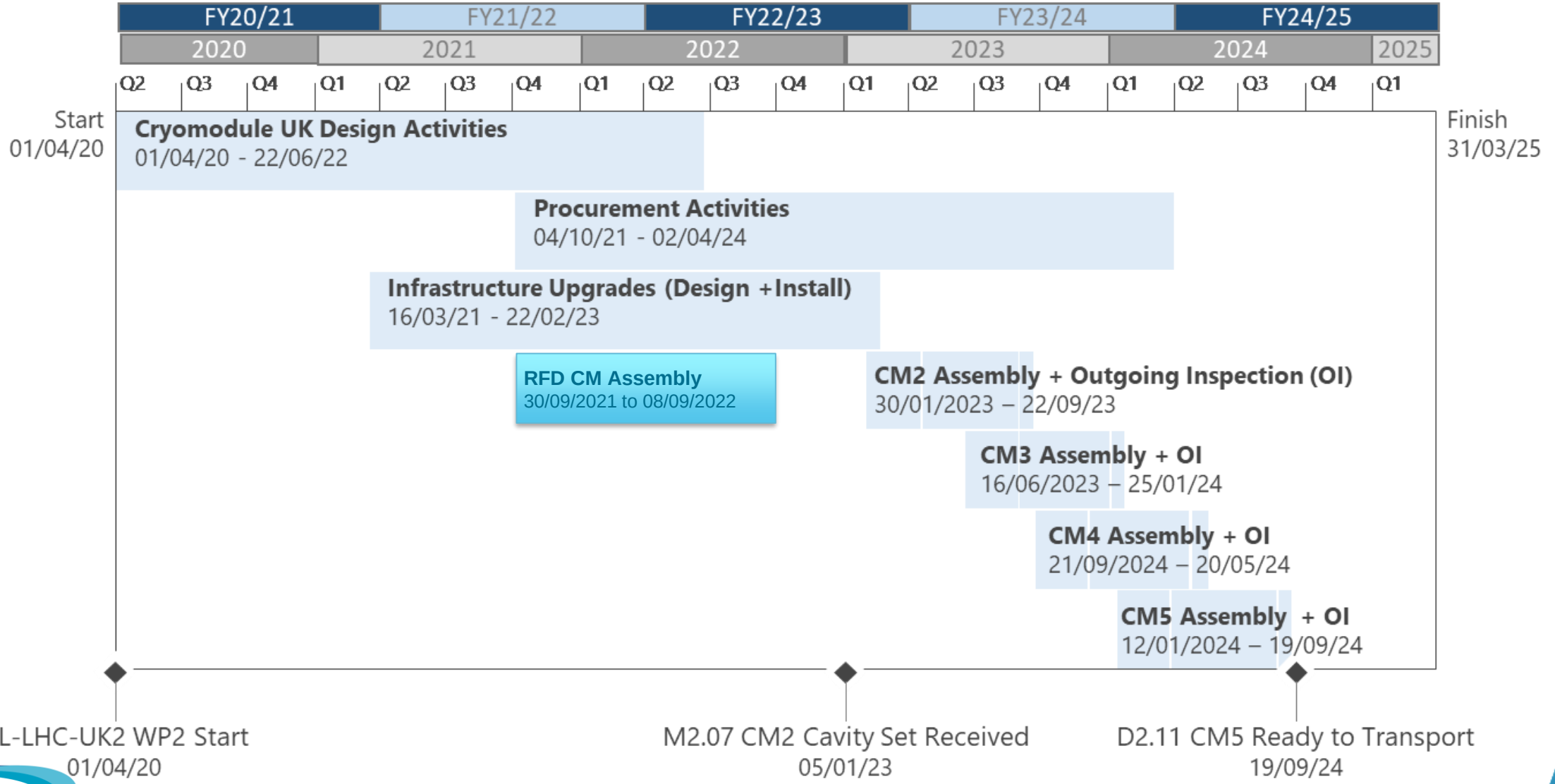
DQW Series Cryomodule



- Design work in progress.
- Aim to be as similar to the RFD Pre-series as possible.
- Conceptual review in March 2022 at the latest.



Timeline for Series Cryomodule Production in UK



Conclusions

- RFD Pre-Series CM assembly will start in the coming weeks
- On track with long lead time procurement/manufacture.
- New infrastructure installed at DL for CM assembly.
- Testing to take place for the CM Transport Frame
- RFD Pre-Series CM assembly should be complete in September 2022
- Work started to adapt design for DQW Series
- Series CM assembly to start at DL in January 2023, with 4 modules complete by September 2024.


Any Questions?