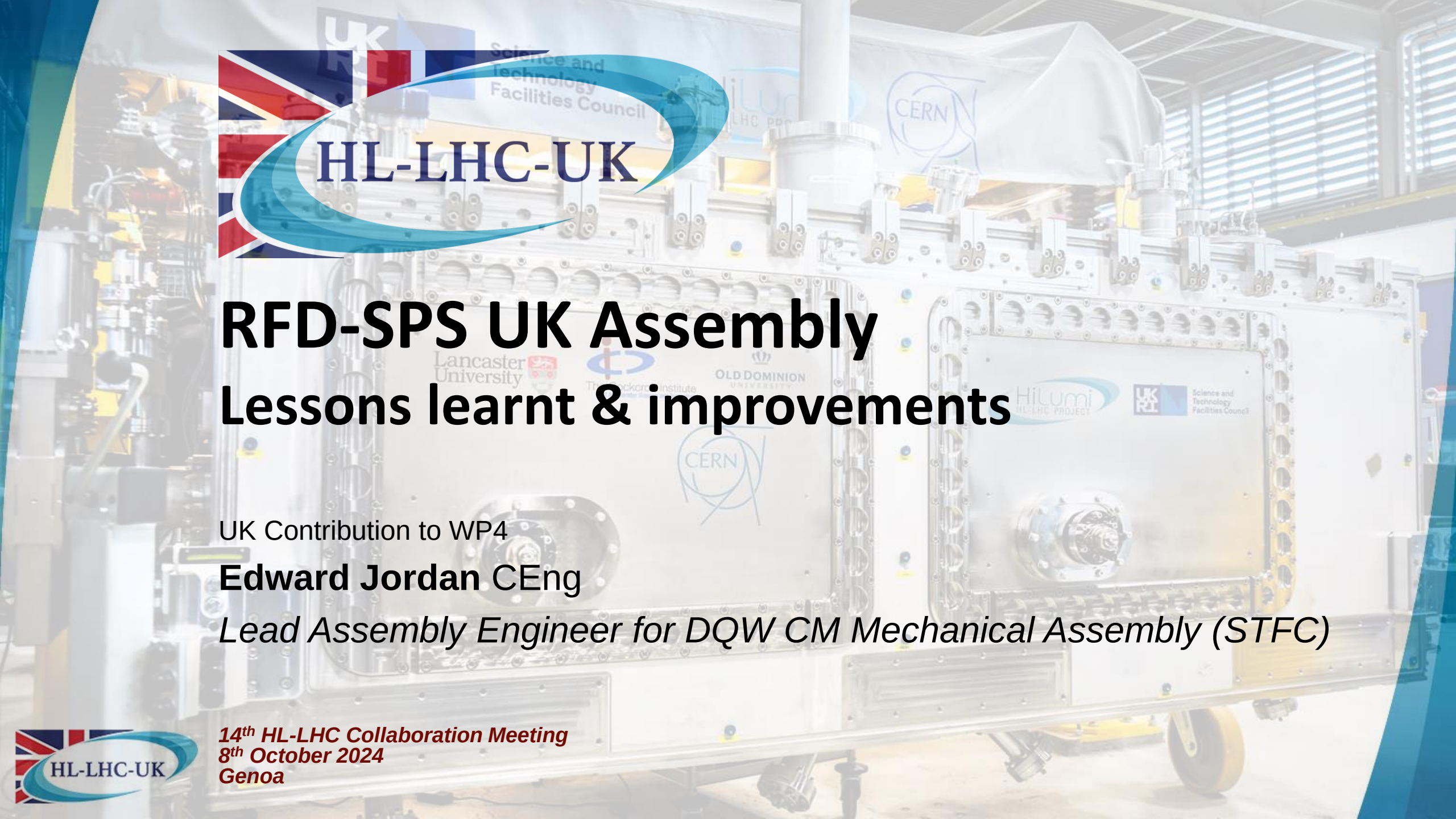

RFD-SPS UK Assembly
Lessons learnt & improvements

UK Contribution to WP4

Edward Jordan CEng

Lead Assembly Engineer for DQW CM Mechanical Assembly (STFC)

14th HL-LHC Collaboration Meeting
8th October 2024
Genoa

Contents (challenges)

- Recap Build Timeline RFD SPS
- Supplier Challenges
- Bellows dents
- Damage to FPC
- Improvements to FPC tooling
- Procedure Bottleneck
- Build Area Workflow

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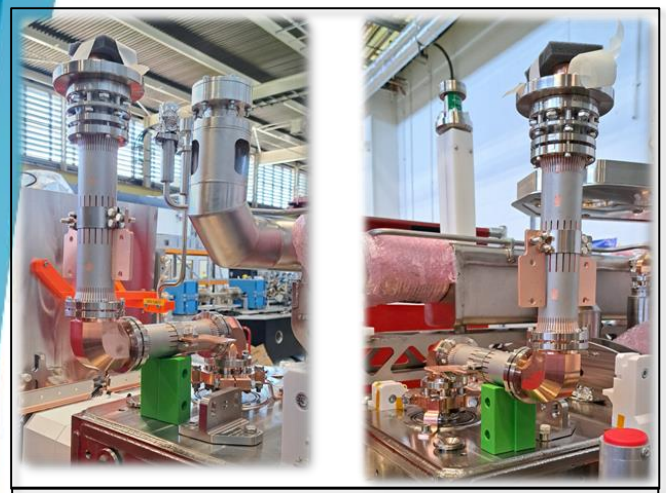
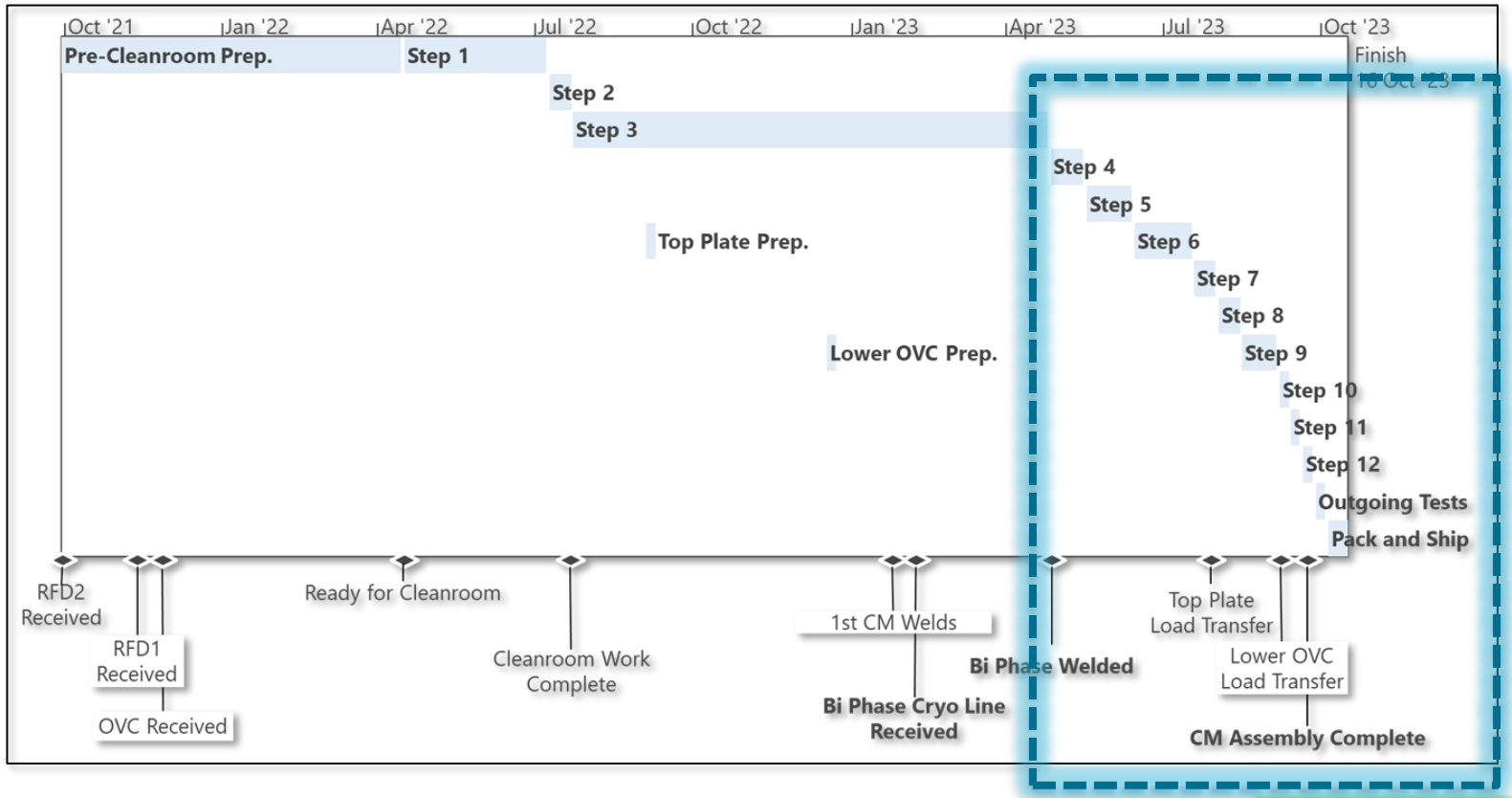
RFD SPS Recap Build Timeline



Co-axials (Step 5) installed before 50k line (Step 4) – had to be removed and reinstalled



- Back Loaded and compressed schedule – less buffer time to reflect and review
- Not following procedure led to steps backwards
- Hard Deadline for RFD-SPS to reach SM18 before Nov 2023

Mitigation

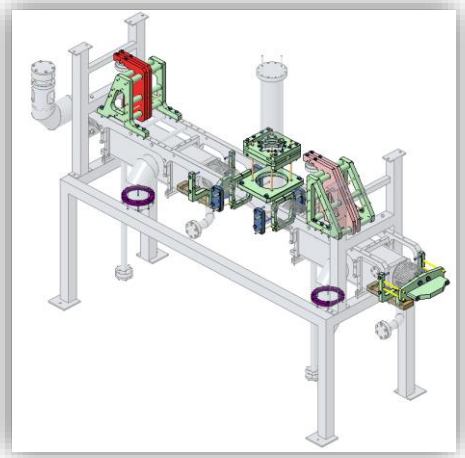
- DQW Series scheduled adequately for tasks to be performed

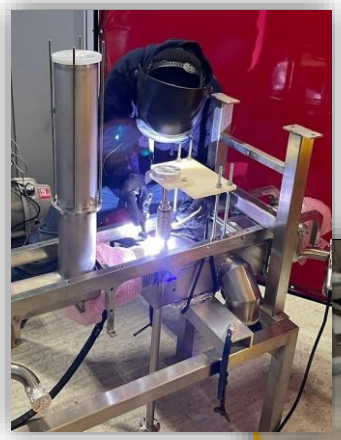
Supplier Challenges

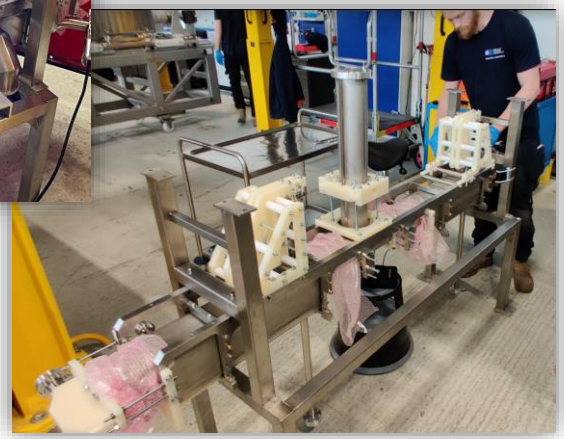
- **RFD SPS Bi-phase** line delivered ~**12mo late**
- **Further delay** to **re-work** & qualify at STFC
- Considerable effort spent to monitor & manage supplier quality

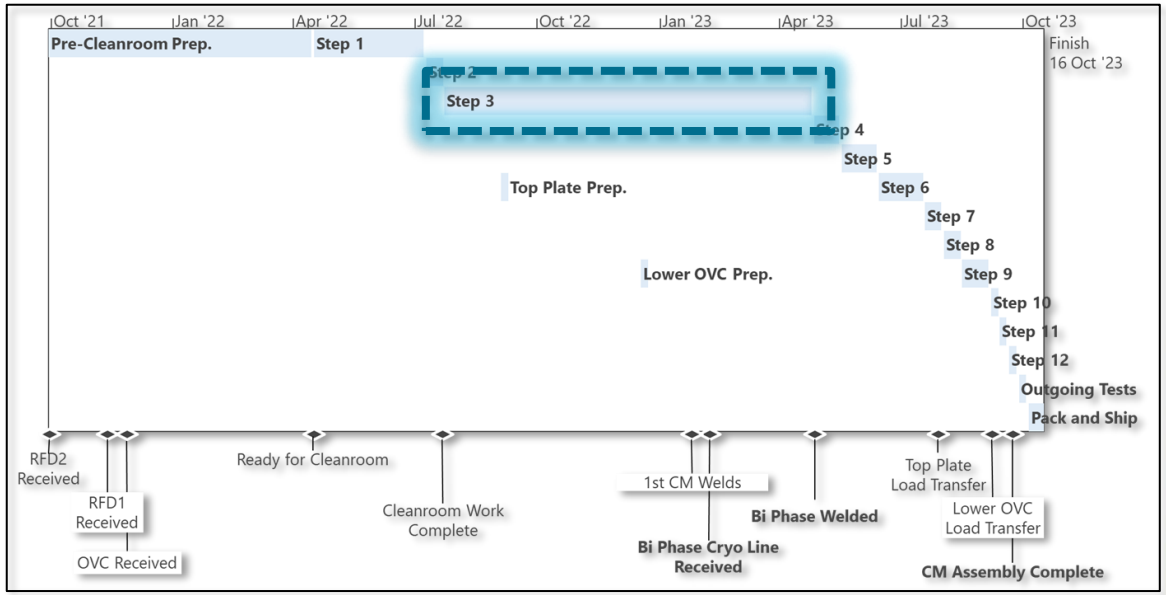
Root Cause

Only 1 bidder - challenging specs & requirements









Mitigation

- DQW Series approach involves greater engagement with suppliers earlier in the manufacturing stage.
- Maintaining strong dialogue to ensure MIPS are followed, and manufacturing issues are approached correctly and timely.
- Managing raw material procurement and free-issuing to suppliers

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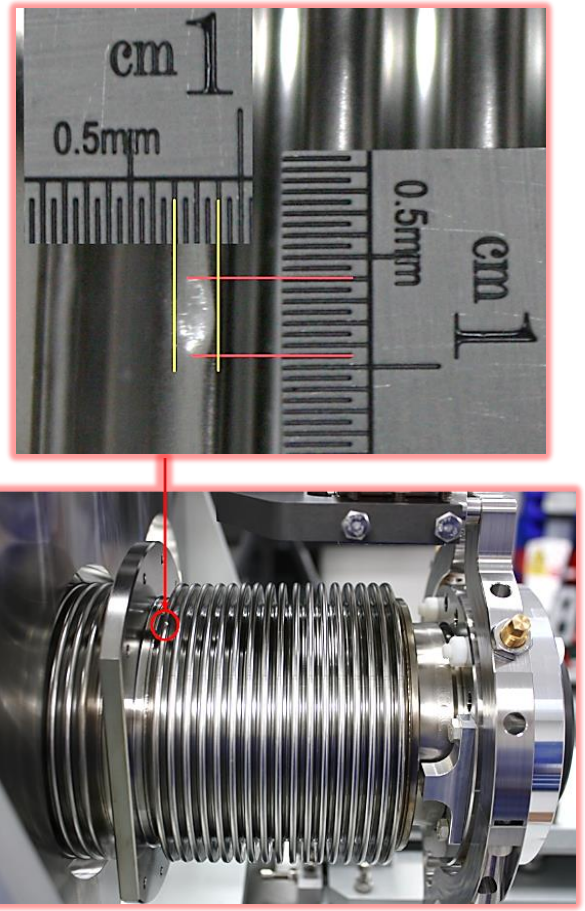
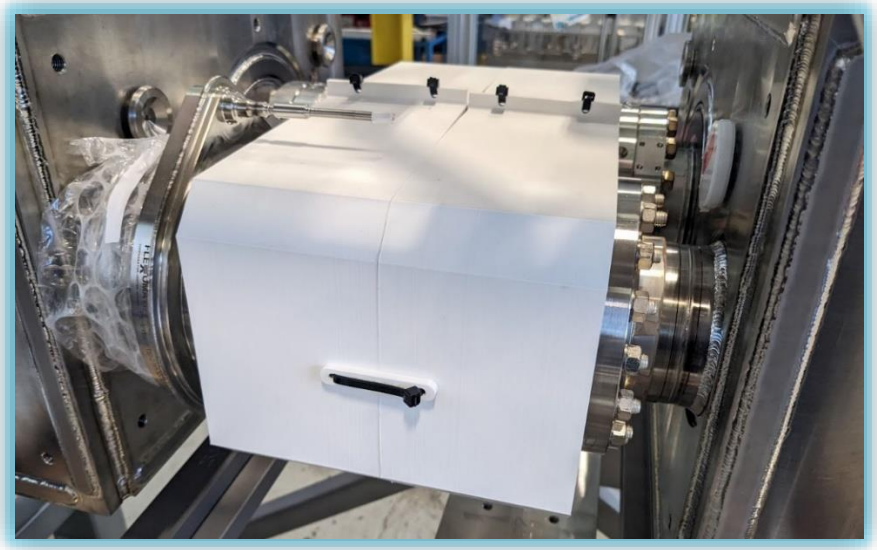
Bellows dents

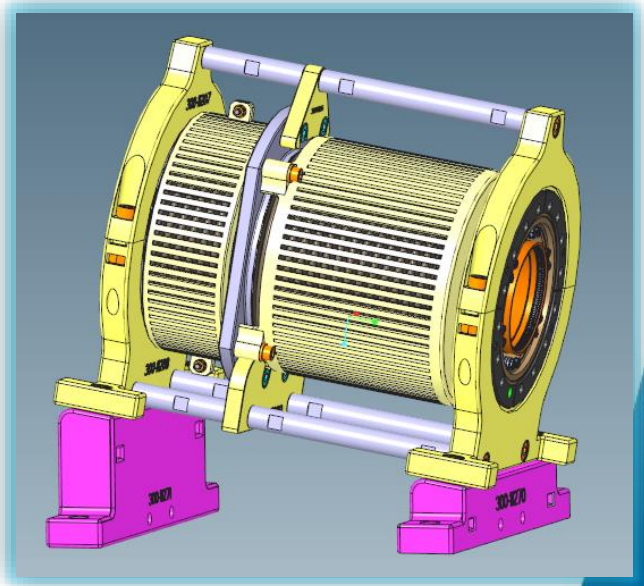


- Handling errors experienced during RFD SPS build
- Some imperfections are the result of not following procedure correctly, some from suppliers, others unknown.
- Difficult to categorically conclude when damages occurred as travellers were quite lightweight

Mitigation

- Bespoke covers design for DQW build for various processing and assembly steps with bellow components





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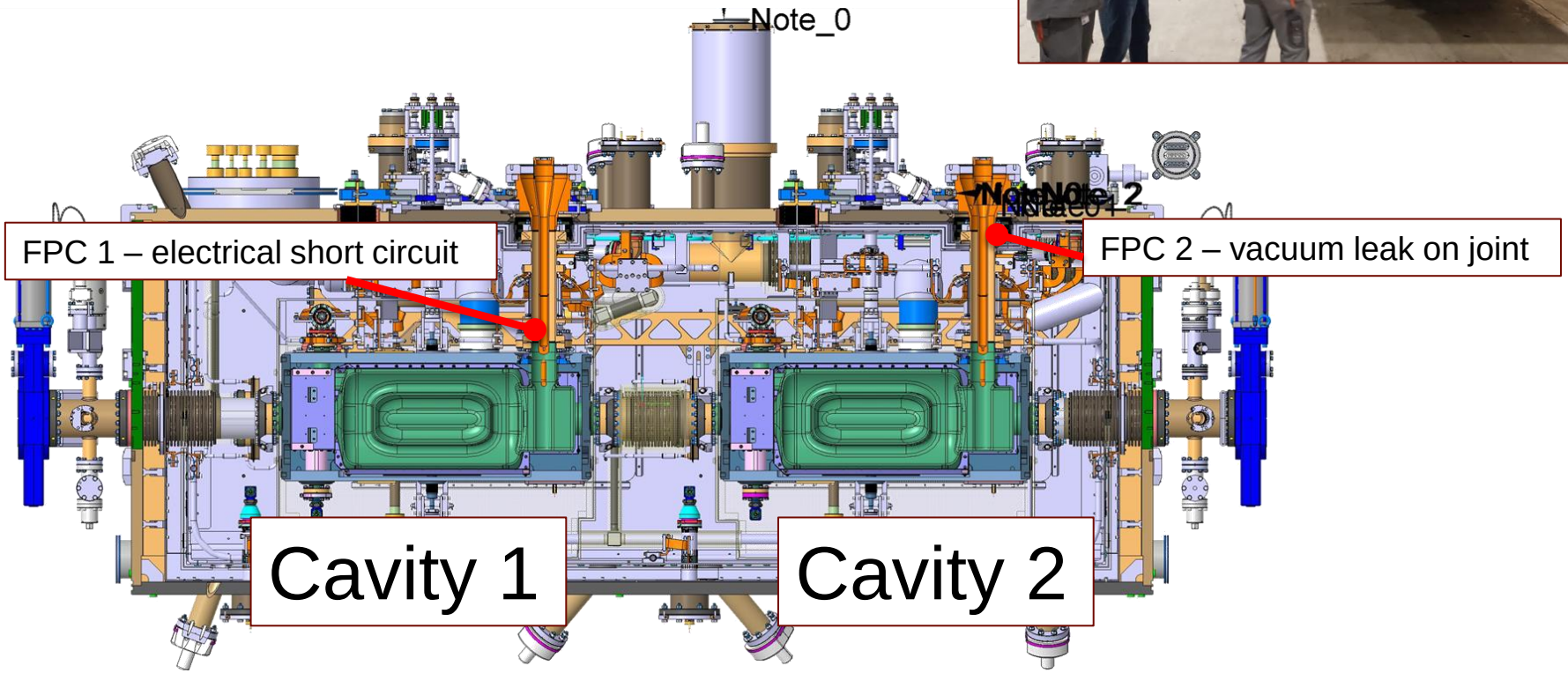
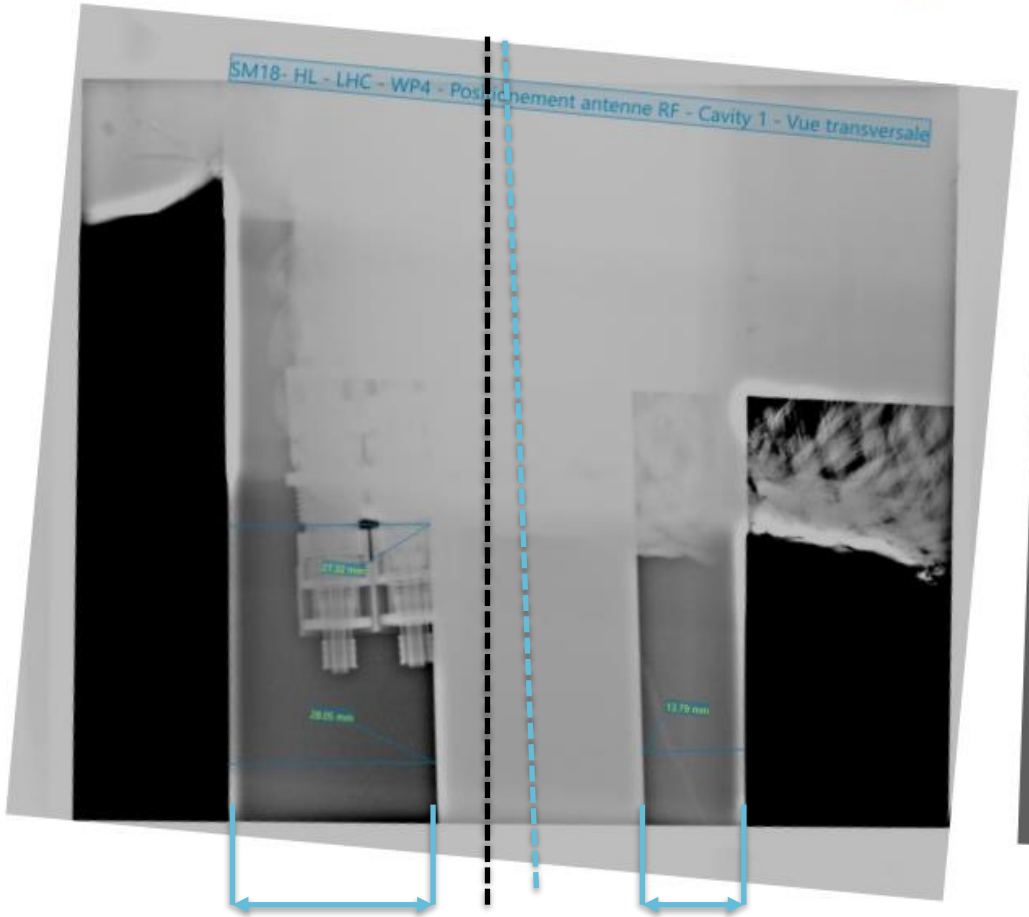
Damage to FPC

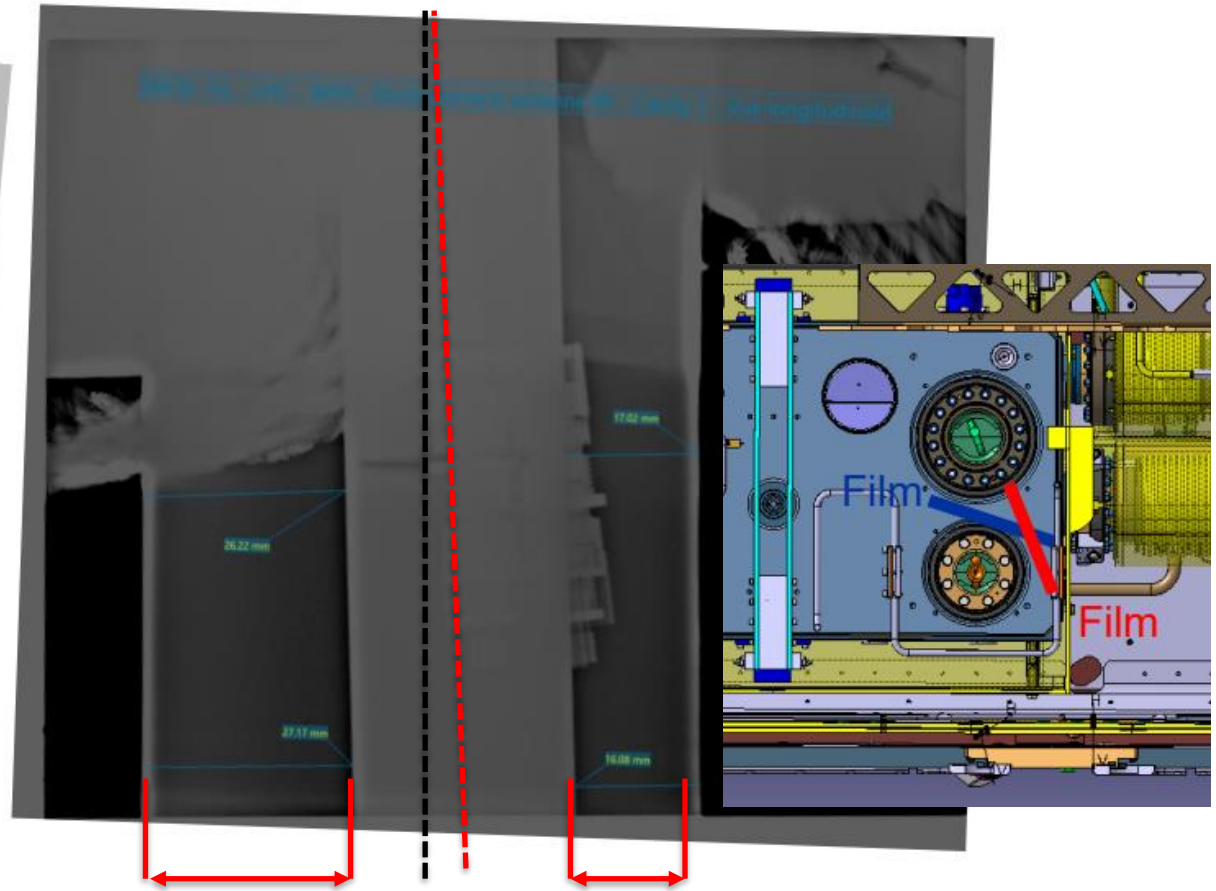
- On arrival of RFD – SPS at CERN
- Electrical Short Circuit on FPC on cavity 1
- Vacuum Leak on FPC hook joint on cavity 2
- X-ray studies undertaken to establish exact hook position.



Results on FPC Cavity #1

https://edms.cern.ch/document/2995980/0.1



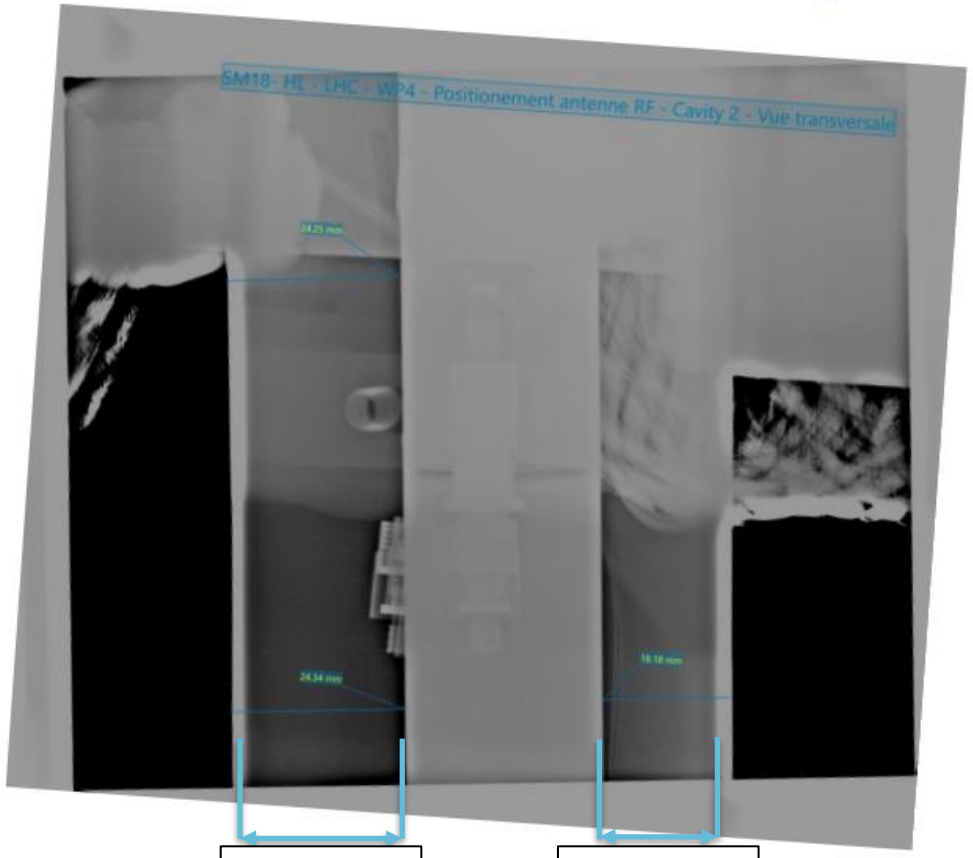


28mm | 14mm | 27mm | 16mm

- Clearance should be equal on both sides – indicating an angular offset between hook and tube (Confirmed by short circuit)

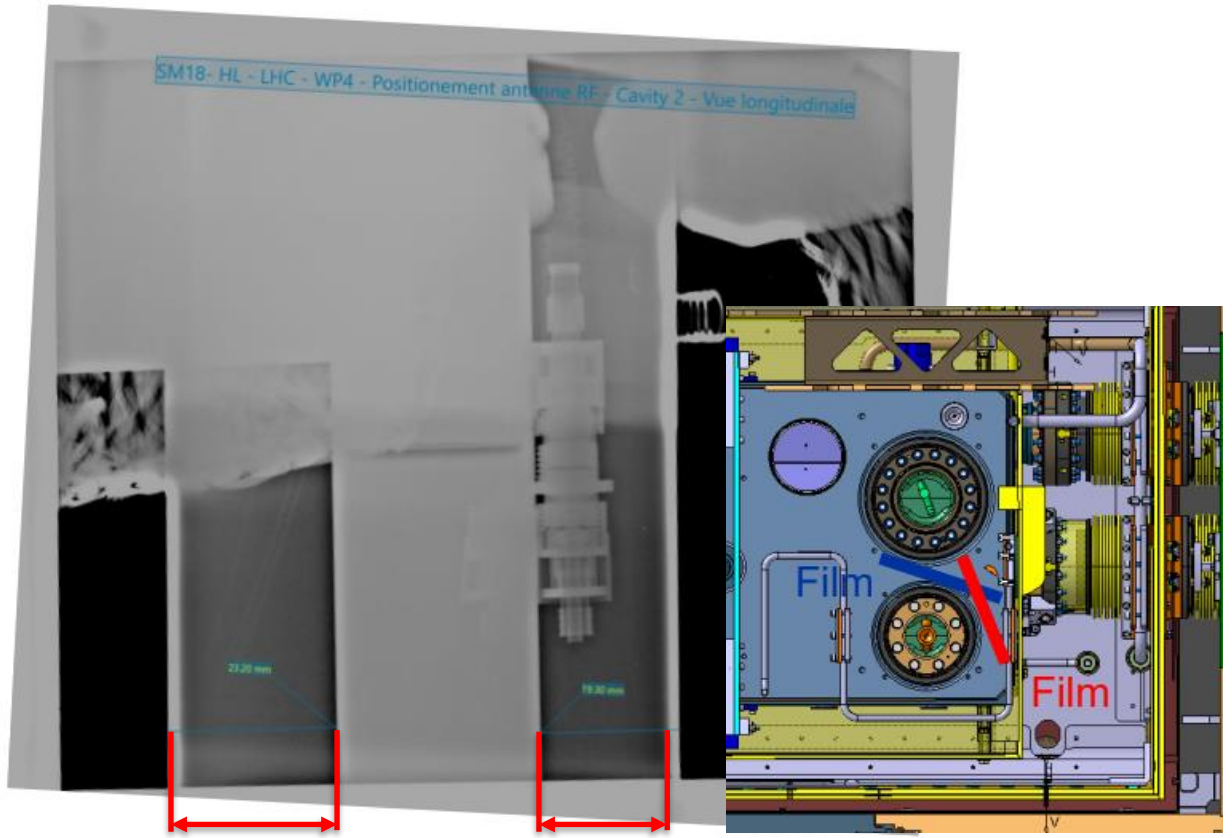
https://edms.cern.ch/document/2995980/0.1

Results on FPC Cavity #2



24mm

18mm



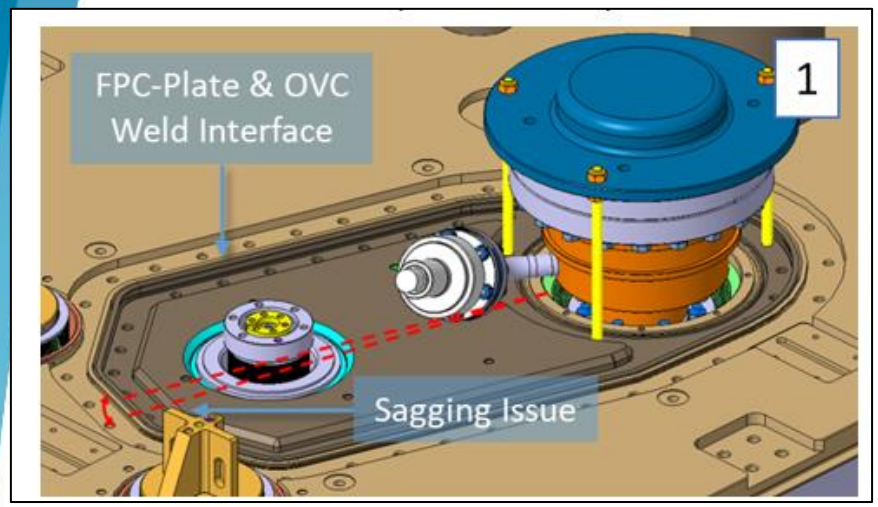
23mm

19mm

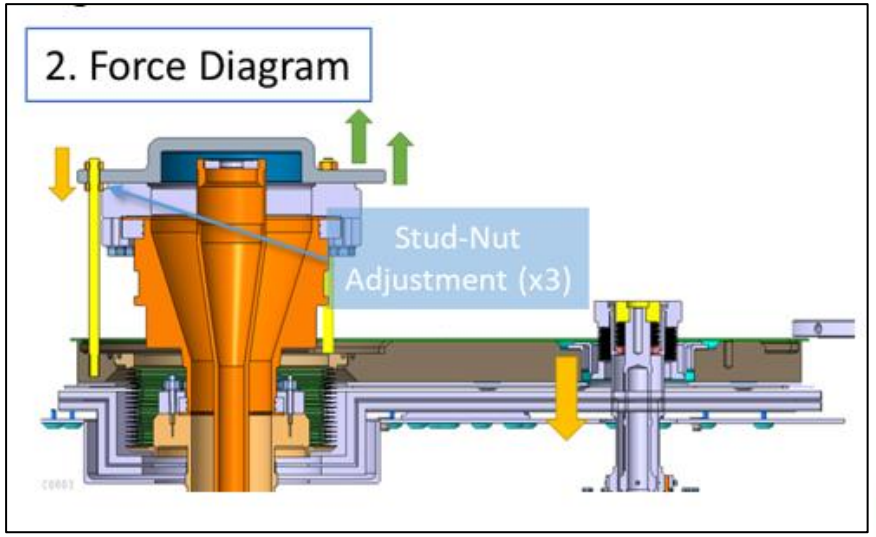
- Again, clearance should be equal on both sides – indicating an angular offset between hook and tube (Confirmed by leak on gasket)

Damage to FPC

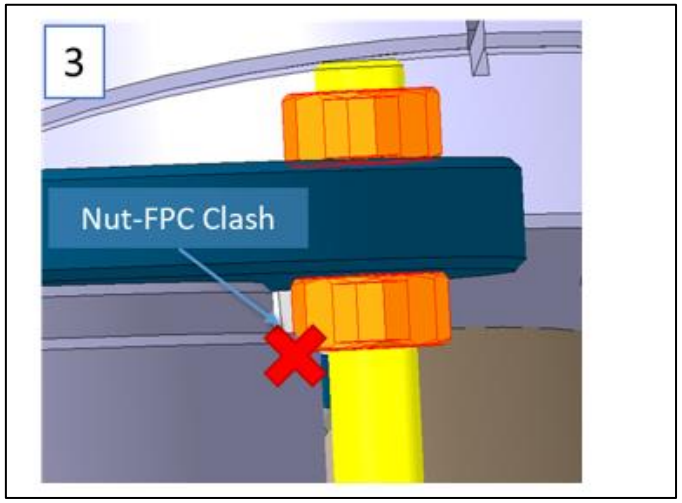
Contributing root causes leading to damage



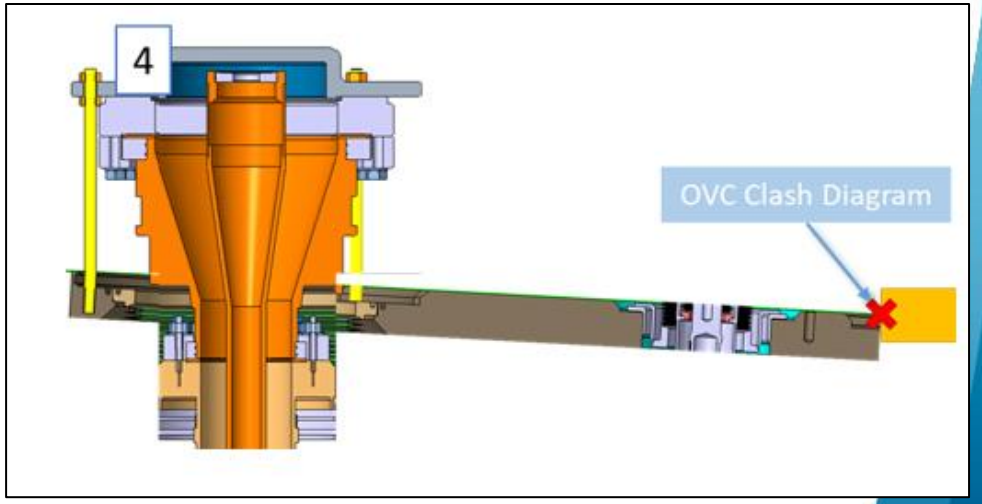
1. The FPC-Plate to OVC interface could not be welded due to cantilever sagging



2. As the weld interface correction was attempted, it's suspected an unknown clash between the FPC-Plate and OVC created the force path through the FPC



3. Correcting the plate pitch was challenging with the FPC-Plate tooling. Due to nut clash on tooling



4. Suspected OVC clash location

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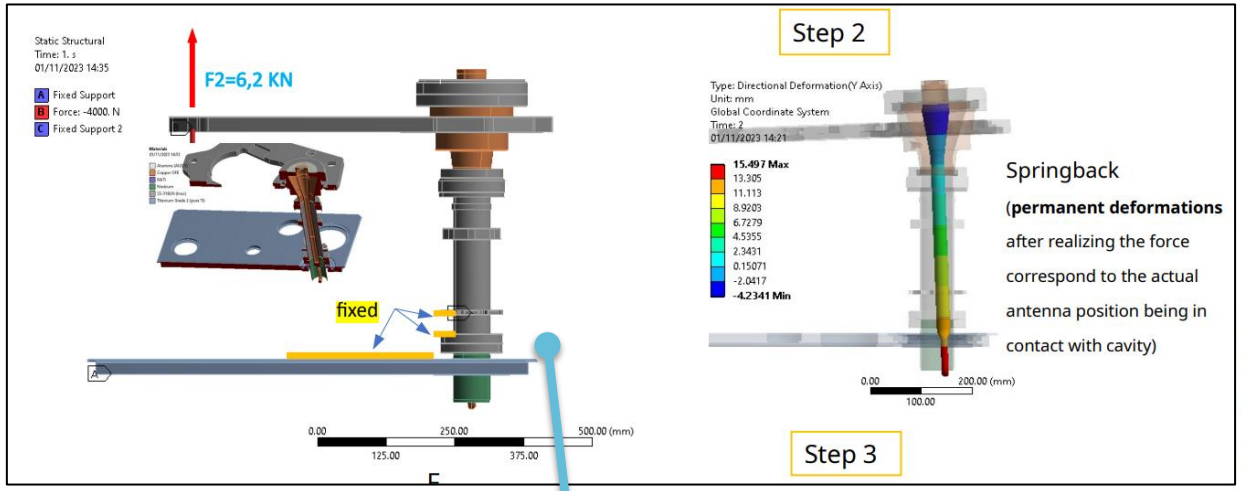
FPC1 Repair

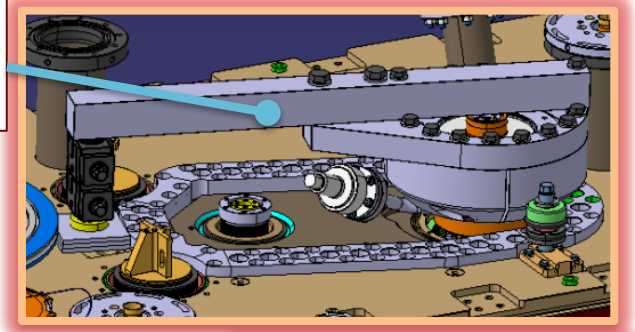
Repair solution designed & developed & implemented by CERN Team.

Challenging to design for all forces involved and account for all mechanical behaviour

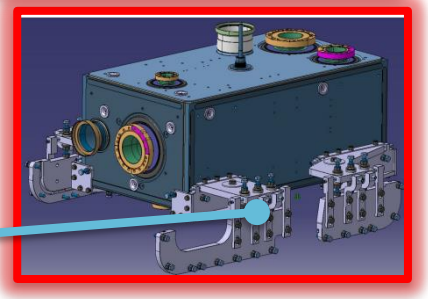


Mechanical Simulations to predict mechanical behaviour and control limits

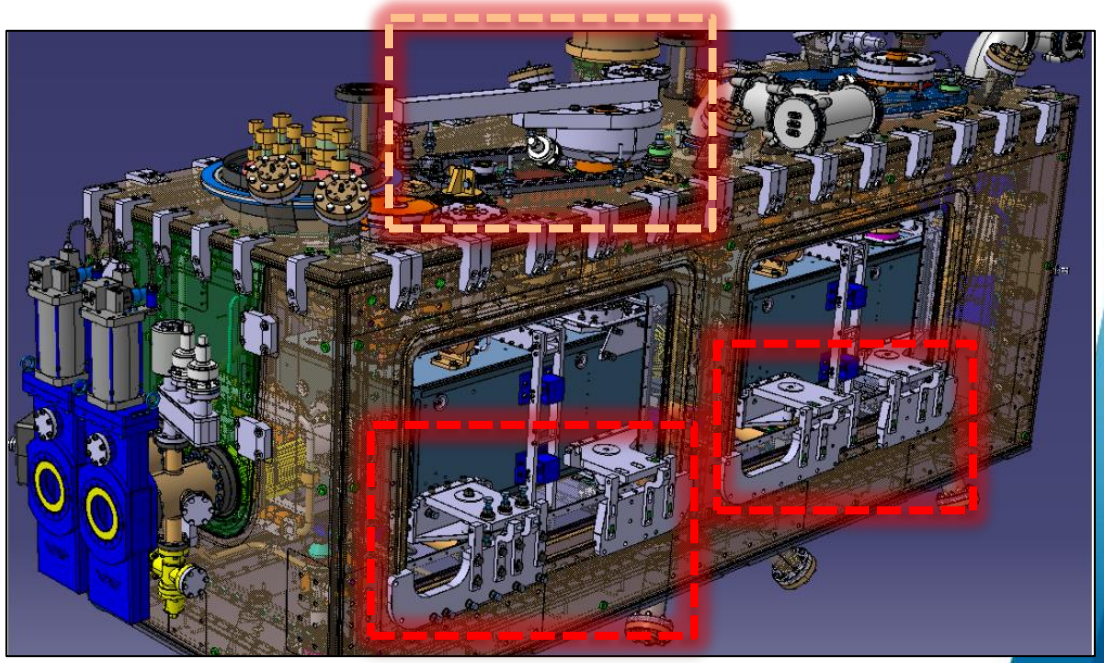
Lever mechanism developed to correct hook angle



Many thanks to all involved in this endeavour!

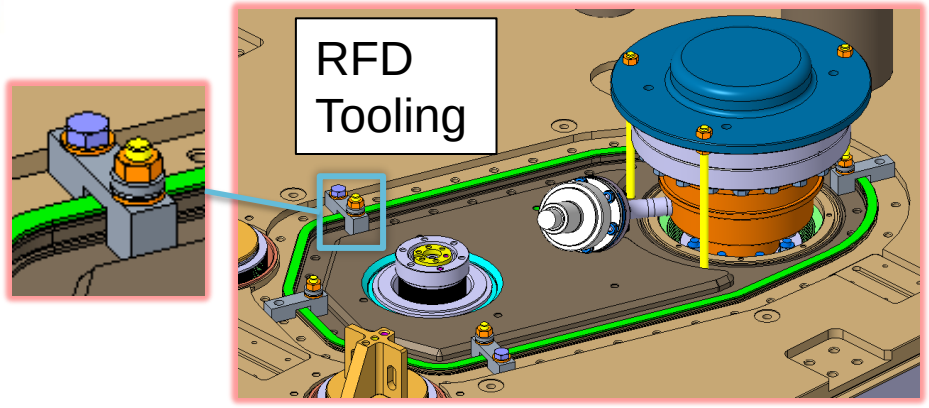


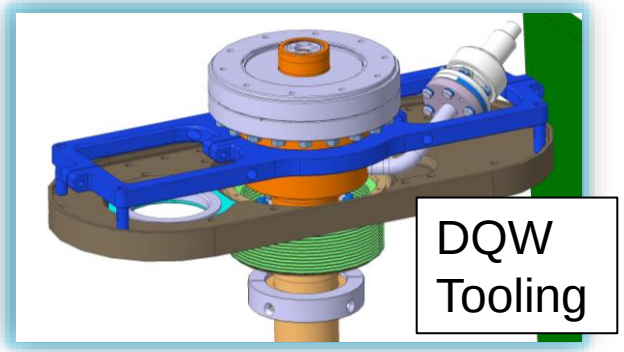
Support tooling to keep cavity in correct global position and prevent further damage



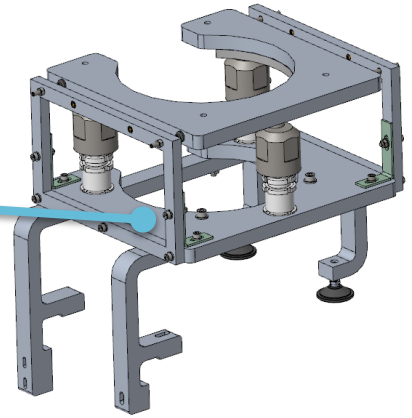
Improvements to FPC Plate handling and installation for DQW (1/3)

- Improved alignment tooling for welding plate to FPC bellows
- Improved Support tooling for FPC plate (mimic interfaces used on Cryomodule)

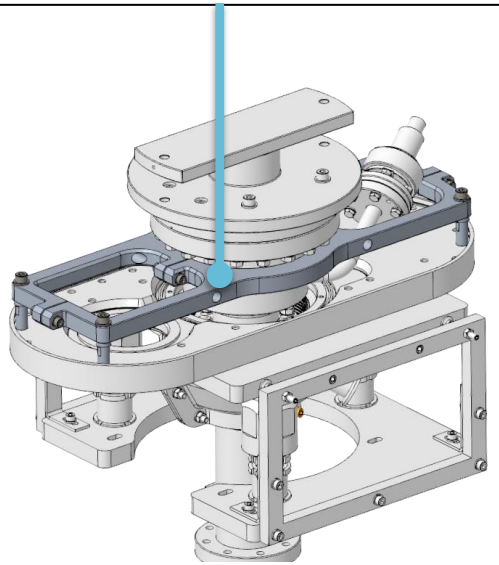


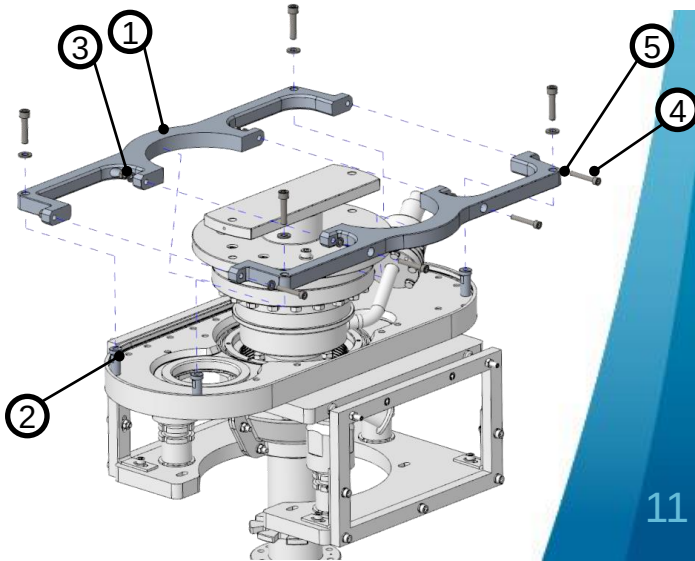


Alignment support for plate welding, designed for orientation w.r.t centre axis



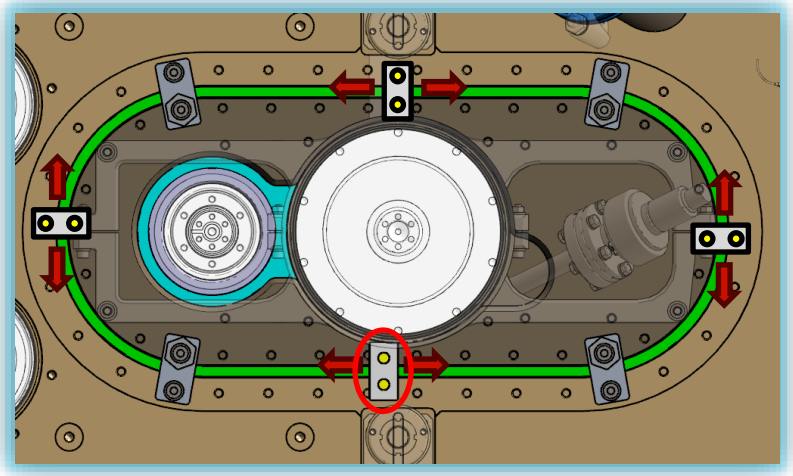
Fixture to support FPC plate during assembly designed to replicate CM intefaces



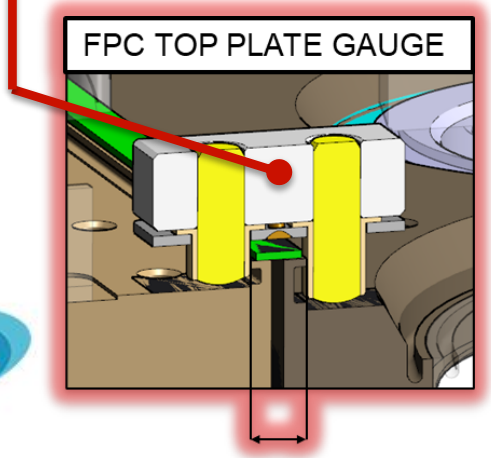


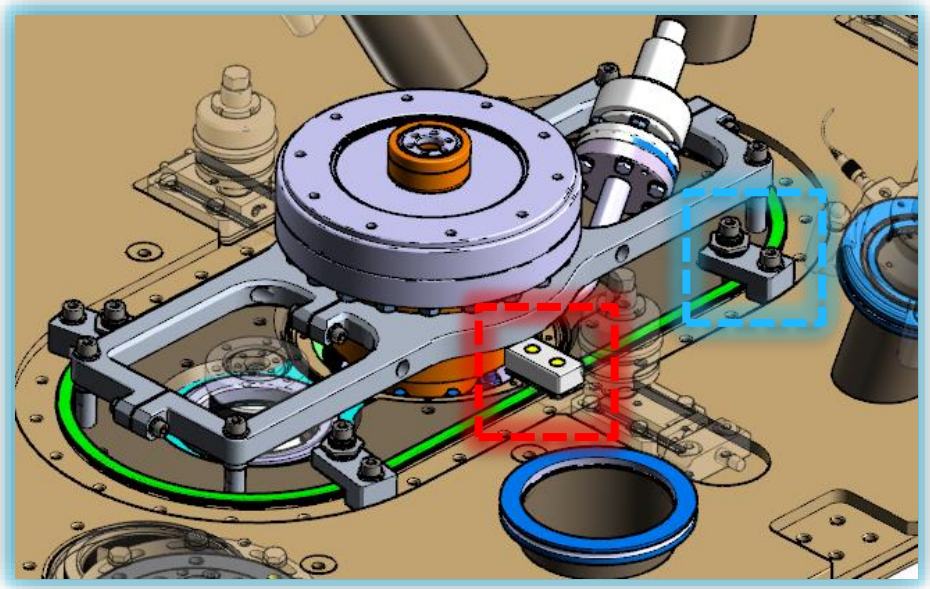
Improvements to FPC handling and installation for DQW (2/3)

- Extra tools designed to check and FPC plate to OVC
- Load path removed between FPC and plate
- Better detail in procedure to control build actions

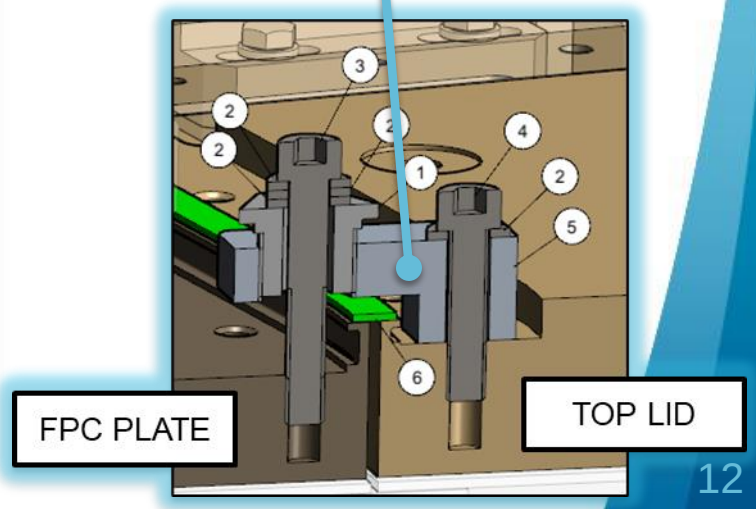


Gauge to align weld features between FPC plate and OVC





Setting tool to control height of Plate locally



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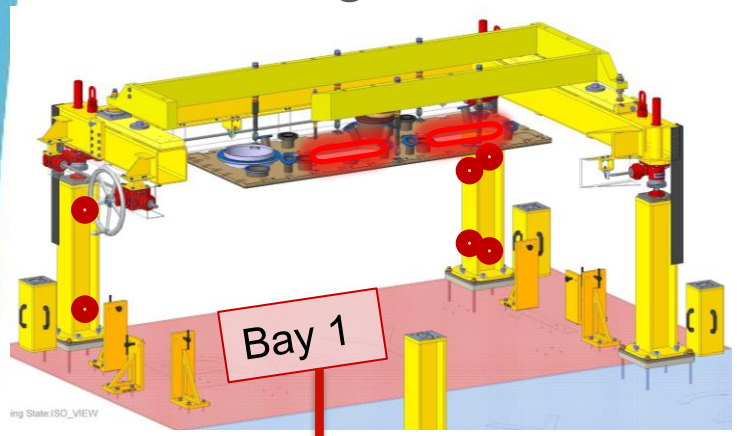
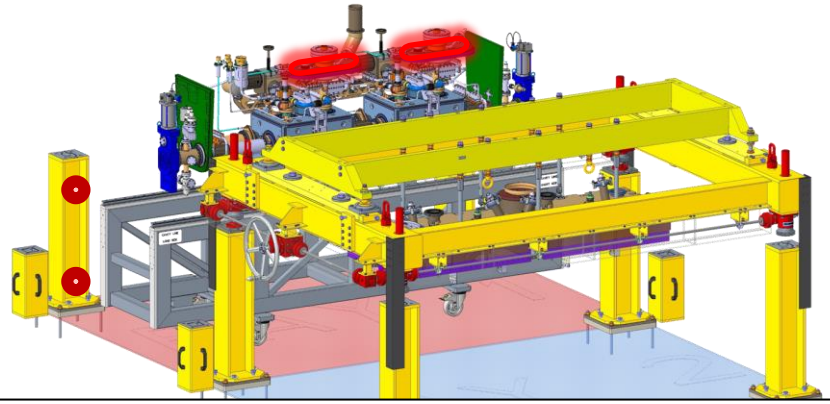
Improvements to FPC handling and installation for DQW

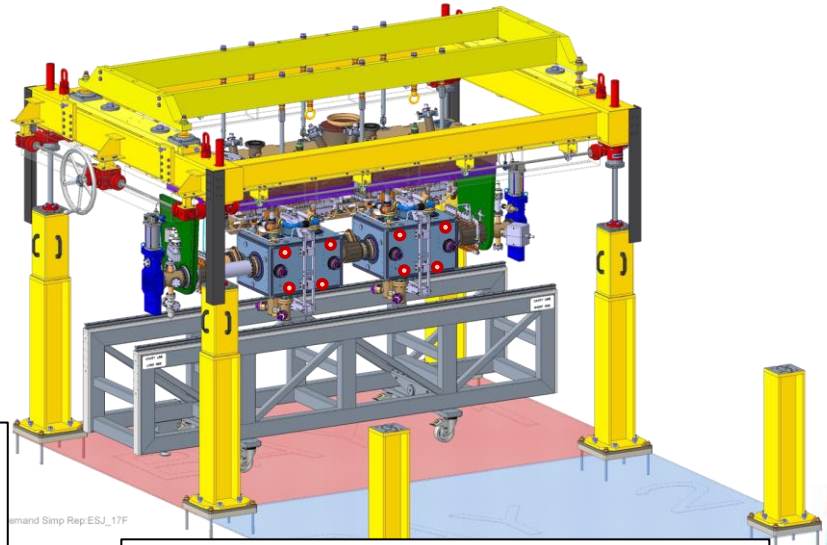
- Improved Survey and Alignment strategy for string & top plate integration
- Intermittent electrical continuity checks on FPC throughout build
- Strain gauges on Blades & FPC can help to identify unscheduled movement during build



Measure position of FPC interface on top plate in Bay 1

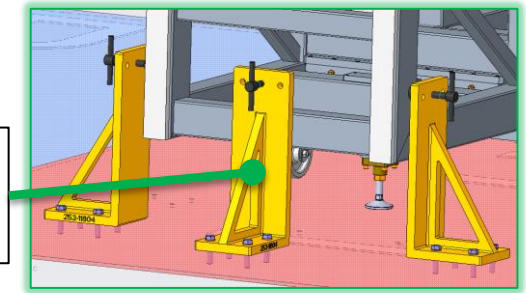


Position string FPC interface accurately to measured position in Bay 1



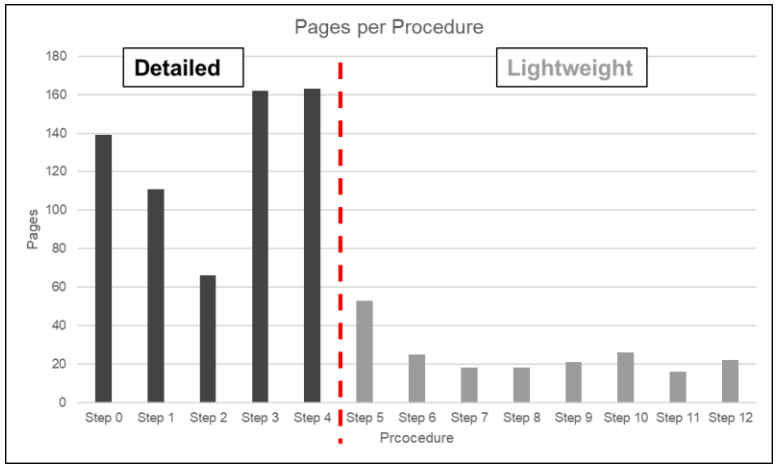
Perform integration of string

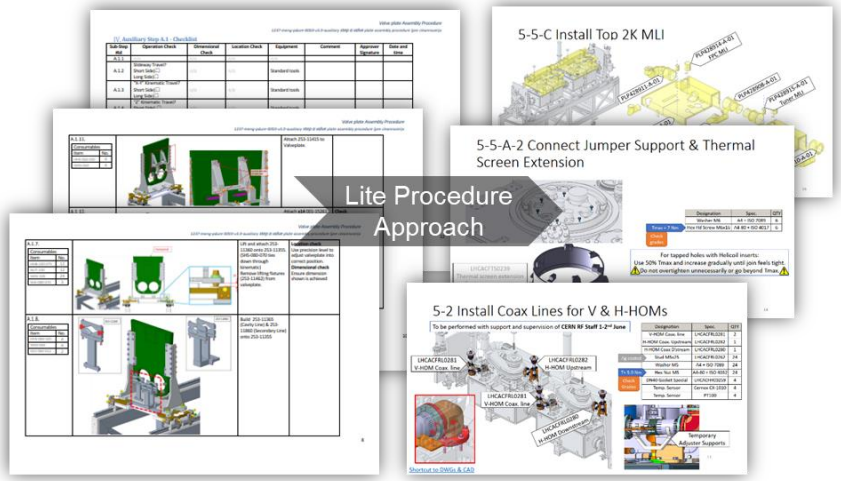
Trolley Positioning Tool



RFD Procedure Bottleneck

- Every build micro-step approved before execution - to resolve challenges and minimise risk
- Procedure execution much faster than production - build caught up with procedure publication
- Light-weight procedure approach developed to satisfy QA, aid technicians and alleviate engineers (between step 4 & 5)





DQW Procedure Status

Poster Step	Procedure No.	Status	Author
-	Aux A - String Loading on trolley	Complete	ESJ
Step 1	Step 1 - String Joints UHV (Cleanroom)	Complete	ESJ
Step 2	Step 2 - FPC UHV (Cleanroom)	Complete	MM
Step 3	Step 3 - Upper Cryoline + Tuner Frame	Complete	DS
Step 4	Step 4 - Upper Line 4k + 50k	In Progress	DS
Step 5	Step 5 - Top Plate integration	In Progress	MM
Step 6	Step 6 - Cavity Support + Load transfer	In Progress	MM
Step 7	Step 7 - Lower Cryoline	Not Started	-
Step 8	Step 8 - MLI 2k	In Progress	POD
Step 9	Step 9 - Thermal Screen + MLI 50k	In Progress	-
Step 10	Step 10 - OVC integration	Not Started	-
Step 11	Step 11 - Secondary Line Vacuum Groups	Not Started	-
Step 12	Step 12 - Doors	Not Started	-
-	Step 13 - Factory Acceptance testing	In Progress	MM
-	Step 14 - Transport	In Progress	ESJ
-	Aux B - Incoming Cavity Operations	In Progress	DJ
-	Aux C - Incoming OVC operations	Not Started	DJ

Mitigation

- DQW procedure development progressing well – need to maintain buffer between publication and execution to allow information digestion in a timely way

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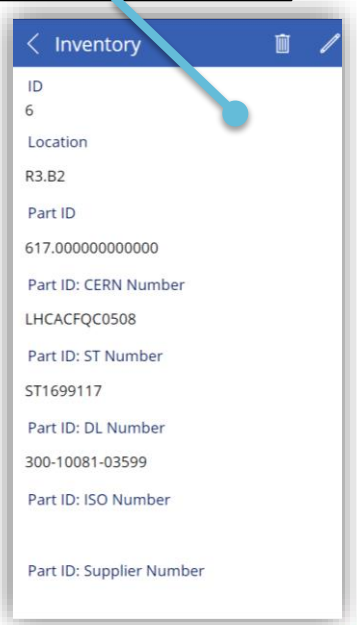
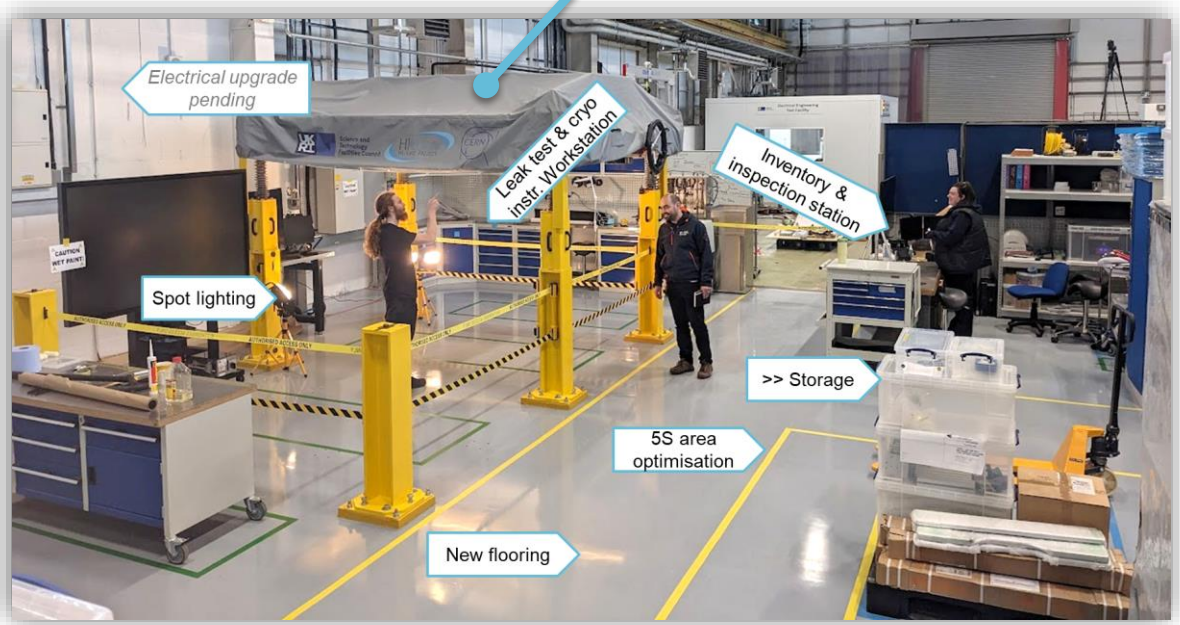
Build area workflow

- Excessive time spent finding components during RFD build
- Issue was exacerbated when build speed was increased
- Relied on communication only - single points of failure if key staff absent
- Some (minor) items re-bought & re-made
- MTF populating was lagging build

Inventory System



Build area physical upgrade



- Improvements for DQW
- Additional QC support staff
- 5S build area optimisation
- New parts management system
- Culture of BOM preparation embedded into team and planning

Mitigation

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Conclusion

- Optimistic for DQW build
- Carrying forward the experience from RFD-SPS (e.g. mitigations)
- Better awareness for identifying and addressing issues
- Ready for the build DQW to begin

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Thanks!
Questions?

14th HL-LHC Collaboration Meeting
8th October 2024
Genoa