



Science and  
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Facilities Council

# RFD Prototype: Assembly lessons learned

12th HL-LHC Collaboration Meeting

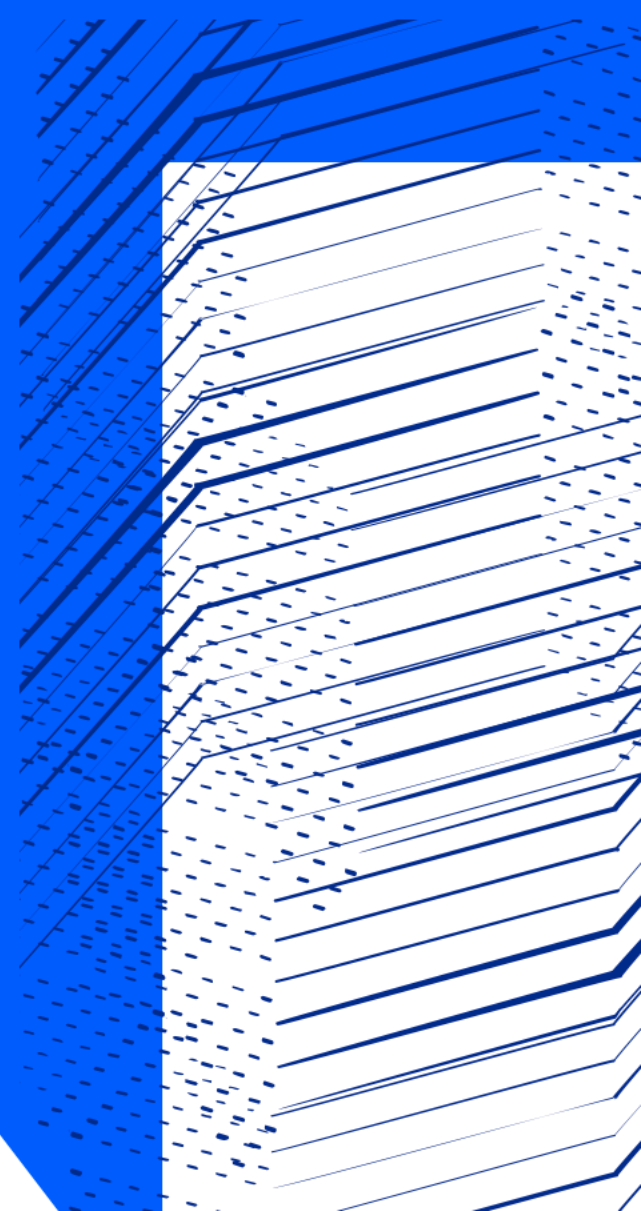
*21/09/2022*

Edward Jordan

Mechanical Project Engineer



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# Progress to Date

21/09/2022

Auxiliary STEP A, B, C, D:

STEP 1:

STEP 2:

## String Cleanroom Assembly

**Steps and Tasks:**

- Step 1:** Cavity equipped, UVV shielded bellows, Extremity vacuum list, Auxiliary STEP A, B & C.
- Step 2:** FPC Assembly with outer pipe & bellows, FPC plate for OVC.
- Step 3:** Upper cryoline, 2K filling line, Upper cryoline support, 4-20K cooling line, HOMS cooling line, Tuner frame, Thermal intercept, Internal support, Magnetic shield.
- Step 4:** FPC screen + MLI, 4K upper line, HOMS thermal links, Thermalization braids 1/2/3, Tuner double pipe + braids.
- Step 5:** SOK outlet line, Cryo instrumentation 2/6, HOMS RF lines, Jumper support, Cryostat copper plate, Assembly files, Safety line screen & MLI.
- Step 6:** FPC plate clamp, Cavity support, FSI flanges, FSI targets, Thermal intercept, HOMS - RF lines, External clamp, Beam screen cooling line.
- Step 7:** Beam screen cooling line, Lower cryogenic line, Cryo instrumentation 3/6, Internal instrum.
- Step 8:** MLI 2K, Antennas - RF lines 3S Cable installation, Magnetic sensors.
- Step 9:** Internal cryo support, Thermalization intercept, Thermal screen, Cryogenic extensions, Thermal screen end panels, Cryo instrumentation 4/6, MLI SOK.
- Step 10:** Antennas - RF lines 2/2 Rigid line, Vacuum vessel, Cryo instrumentation 5/6, FSI flanges, Vacuum vessel, HOMS - RF lines, External clamp, Vibe plate clamp.
- Step 11:** Vacuum instrumentation, Extremity vacuum list, Vacuum blow off valve, STEP 11 - Assembly files, External heaters and sensors.
- Step 12:** Doors, Level gauge and Helium guard, External heaters and sensors, STEP 12 - Assembly files.

**Transport:** Transport tooling, Lifting blocks, Transport tooling, Cryostat transport tools.

**M7 tests:** Cryogenic safety extension, Jumper, Inclinationmeter, Support jack.

**SPS:** Cryogenic safety extension, Jumper, FSI flanges, Inclinationmeter, Support jack.

# Progress to Date

Auxiliary A, B, C, D:

STEP 1:

STEP 2:

} **String Cleanroom Assembly**

**Activities performed in clean room**

**Auxiliary STEP A, B & C**  
Cavity string preparation before clean room

**Assembly files**

- Auxiliary step A – Valve plate assembly - See EDMS 2507918
- Auxiliary step B – String trolley assembly - See EDMS 2677539
- Auxiliary step C – Alignment pre clean room - See EDMS 2707042

**Step 1**

- 1 Take the assembly prepared in auxiliary step A in clean room
- 2 Install the cavity on the assembly trolley
- 3 Connect the cavity line PIMS to extremity chamber then to cavities
- 4 Leak test

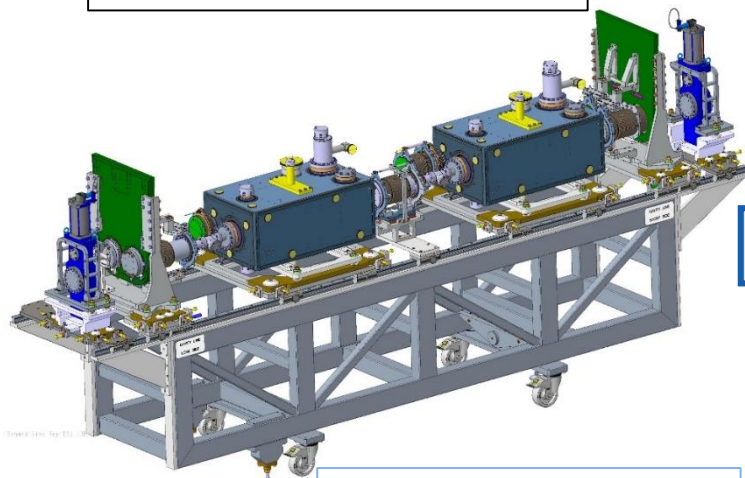
**Step 2**

- 1 Positionate the FPC plate on the Helium tank
- 2 Install FPC hook and outer pipe
- 3 Leak test

**EDMS Numbers:**

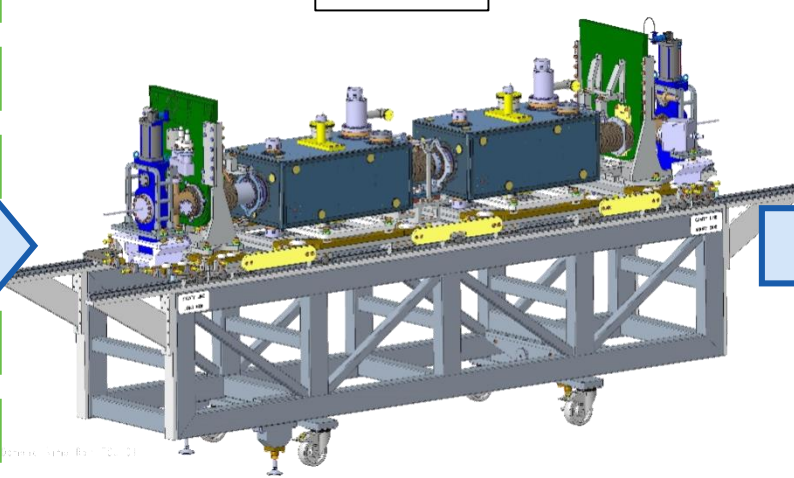
- Auxiliary Step A — EDMS: 2507918
- Auxiliary Step B — EDMS: 2677539
- Auxiliary Step C — EDMS: 2707042
- Auxiliary Step D — EDMS: 2731628
- Step 1 — EDMS: 2736227
- Step 2 — EDMS: 2757741

Auxiliary Steps A,B,C,D

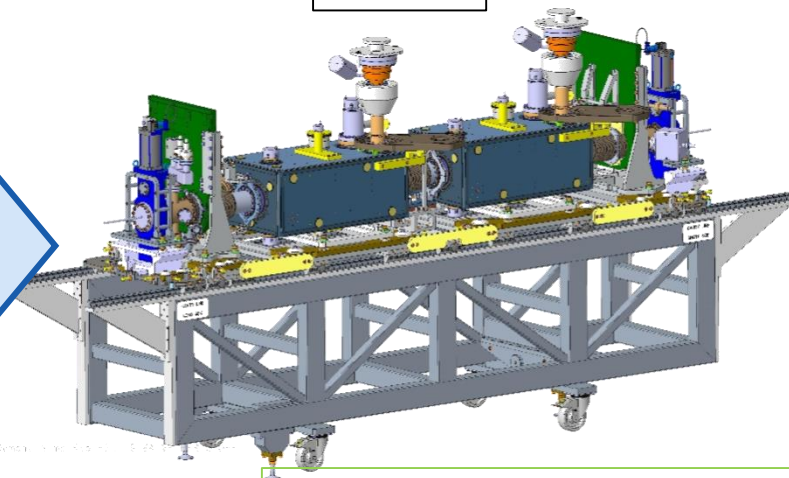


Outside Cleanroom

STEP 1



STEP 2



Inside Cleanroom (ISO4)



String on Trolley (pre-cleanroom aligned)



PIMS + Cavities cavity line Joints made (Cleanroom ISO4)



FPC installed to cavity x2 (Cleanroom ISO4)

# Engineering challenges

## Challenge #1

**Complexity of design**

## Challenge #2

**Studs on Cavity String Joints**

## Challenge #3

**Scheduling**

# Engineering challenges

## Challenge #1

**Complexity of design**

## Challenge #2

Studs on Cavity String Joints

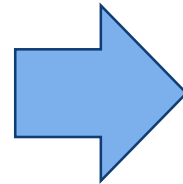
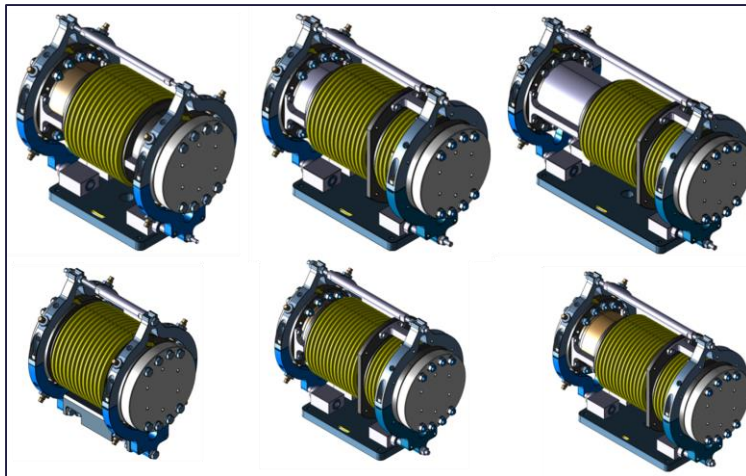
## Challenge #3

Scheduling

# Challenge #1

## Complexity of design

- Auxiliary Steps ABCD comprises 200+ discrete steps
- Over 400 unique components
- Easy to confuse items with one another



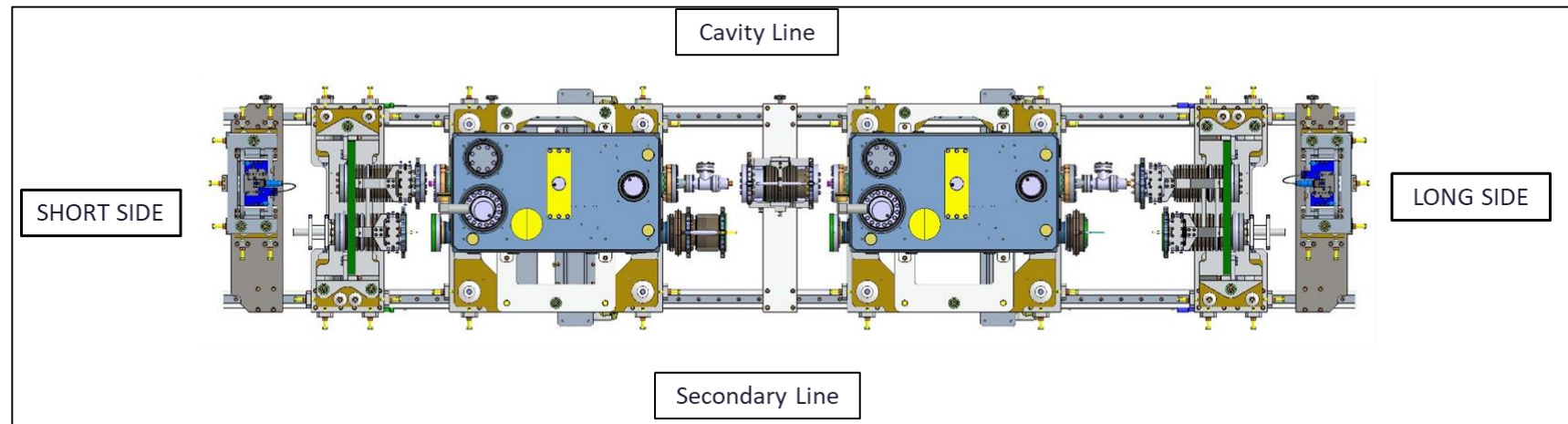
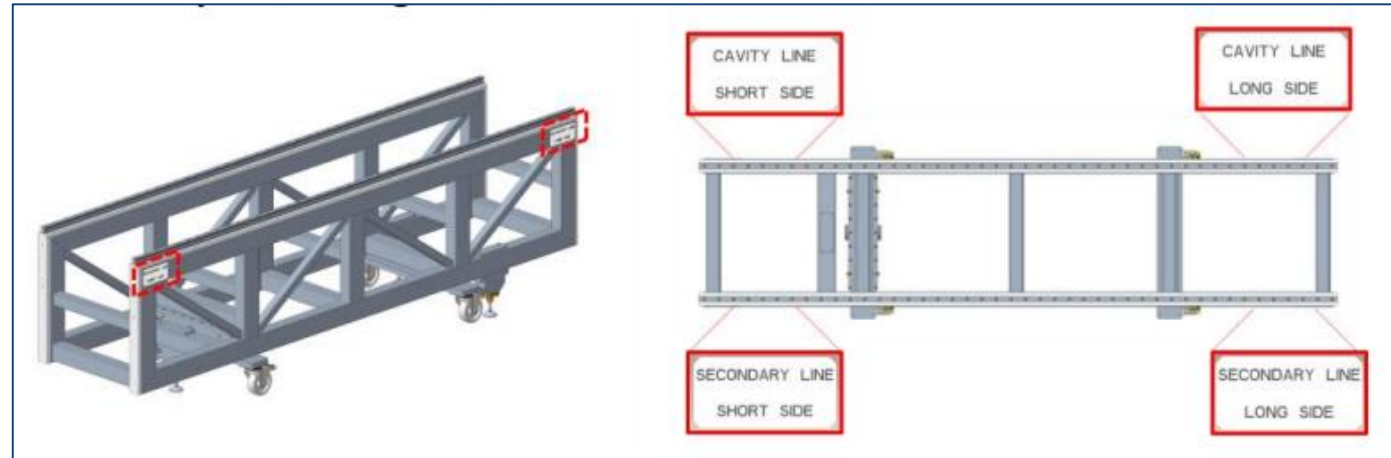
6x Plug in Modules (PIMS)

- Each unique position and orientation captured correctly

# Challenge #1

## Complexity of design

- Ensure common nomenclature observed throughout



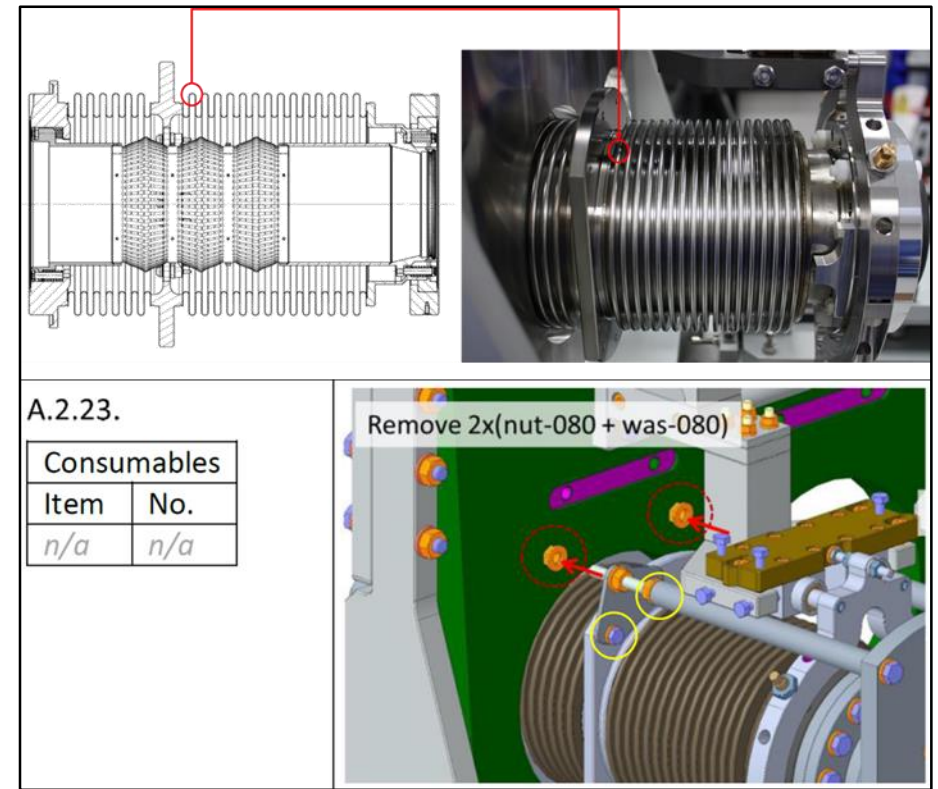


# Challenge #1

## Complexity of design

RFD Short CW Transition LHCVBMCC0033 Dent | LHC-ACFVW-QN-0001

- Error during assembly led to a dent on the secondary line CWT,
- Highlighted the need to follow assembly procedures carefully,
- Non-conformance is to be closed once secondary line vacuum integrity has been demonstrated, (coming weeks)



# Engineering challenges

Challenge #1

Complexity of design

**Challenge #2**

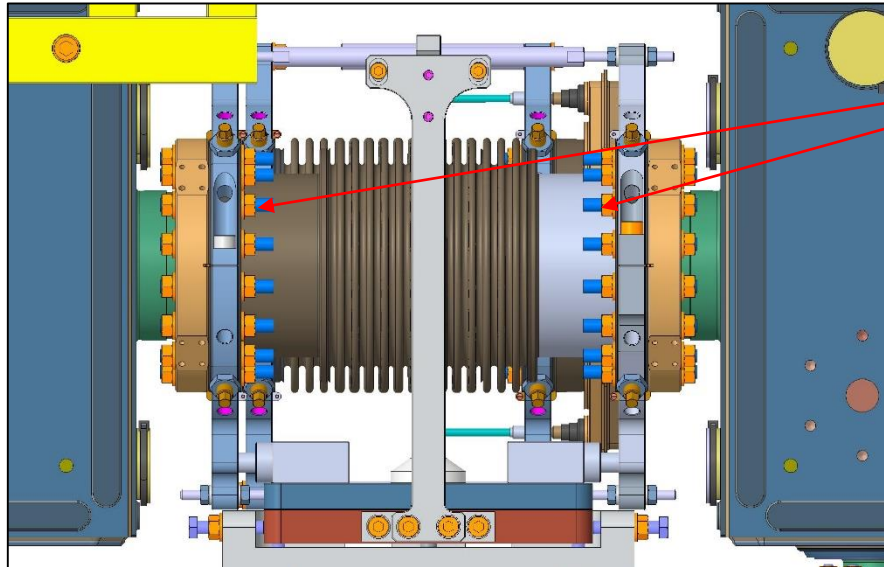
**Studs on Cavity String Joints**

Challenge #3

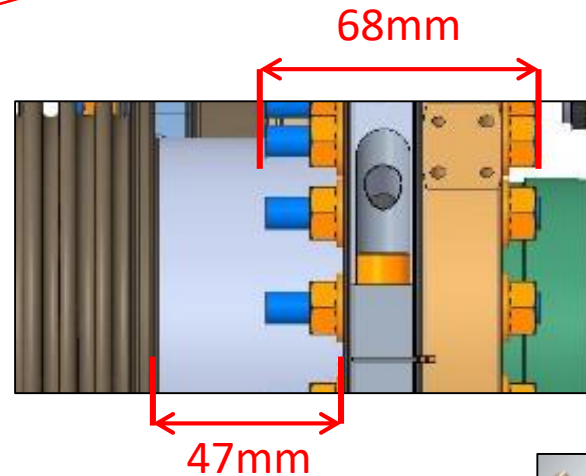
Scheduling

# Challenge #2

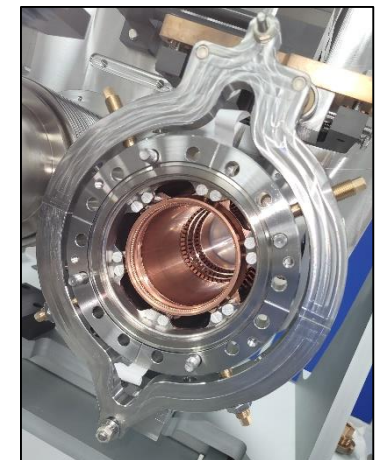
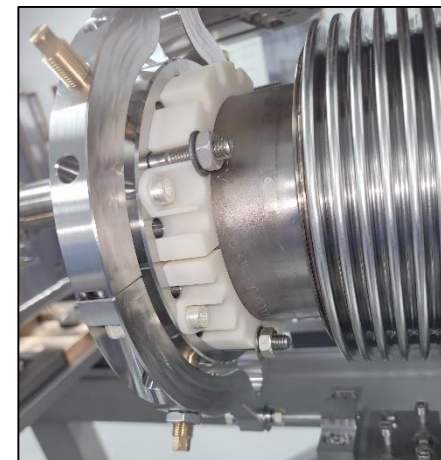
## Studs on Cavity String Joints



- Studs are longer than clearance behind flange
- Studs need to be pre-placed into PIMS before joint is made



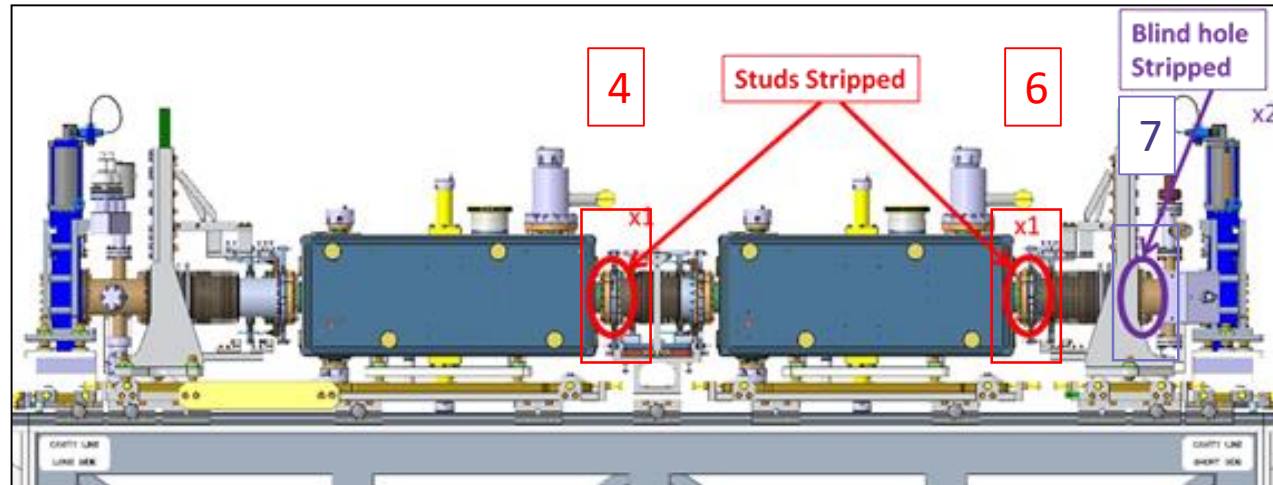
- Therefore, **studs cannot be replaced once joint operation begins**



# Challenge #2

## Studs in Cleanroom

Threads Stripped on String Joints (STEP 1) | LHC-ACF\_A-QN-0001



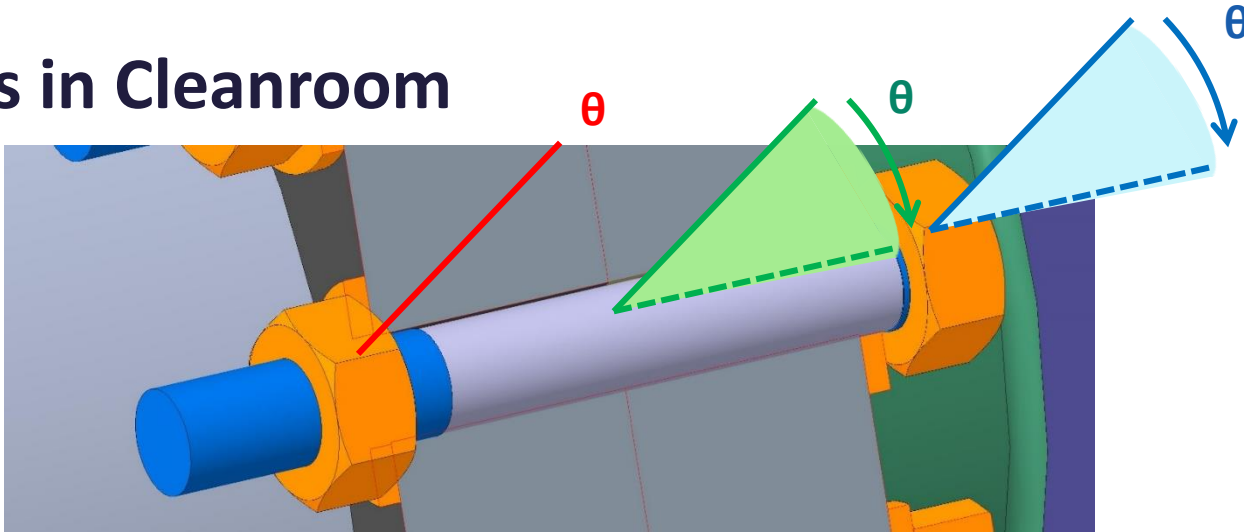
Cause: combination of poor thread form on fasteners & difficulty of joint arrangement to gauge force/feel feedback during torque setting.

Remedy: blind holes and stud threads re-tapped in-situ in cleanroom, vacuum integrity check passed.

- Joints 4, 6, 7 experience thread failures

## Challenge #2

### Studs in Cleanroom



- When torque is applied to the Nut on the stud, there is no way to monitor if the stud is rotating/stationary
- Silver coating of nut means thread form is inconsistent
- Therefore, difficult to monitor force feedback and stud position during torque application
- Remedy for the series will to ensure the Studs used have a slot or equivalent to prevent rotation

# Engineering challenges

## Challenge #1

Complexity of design

## Challenge #2

Studs on Cavity String Joints

## Challenge #3

Scheduling

# Challenge #3

## Scheduling (Covid / Brexit / Global Issues )

- Arrival of long lead items impacting build phases
  - Outer Vacuum Chamber (Valveplates are the first item on string assembly)
  - Cryoline (Main item installed on step 3)
- Also delays to short/medium lead time items and tooling impacting the build & mechanical design
  - Cleanroom tooling – delays in the manufacture of these items impacted into other work streams
  - String Lifting equipment – “
- Availability of these items makes it difficult to plan visits from CERN personnel
  - FPC Install
  - FSI install
  - Various Instrumentation install
- New trade barriers between EU + UK has drained project resource (Brexit)
  - A logistical issue that has consumed a lot of resource from staff not specialised in customs/ logistics.

# Thank you for your attention,

## Questions?

