



Readiness of WP6A cold powering system for the IT String

Yann Leclercq on behalf of WP6a

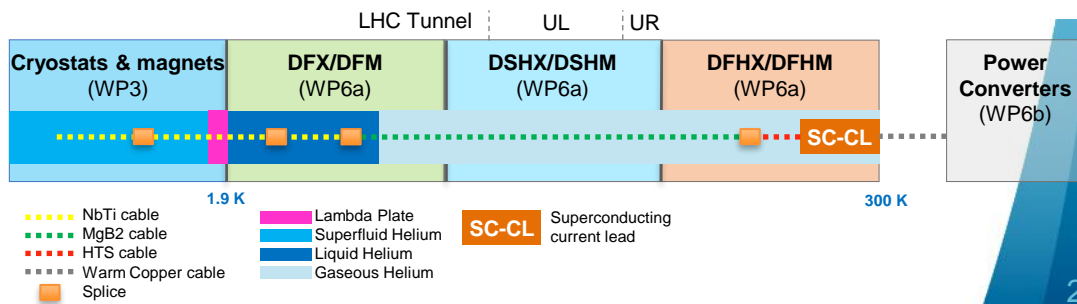
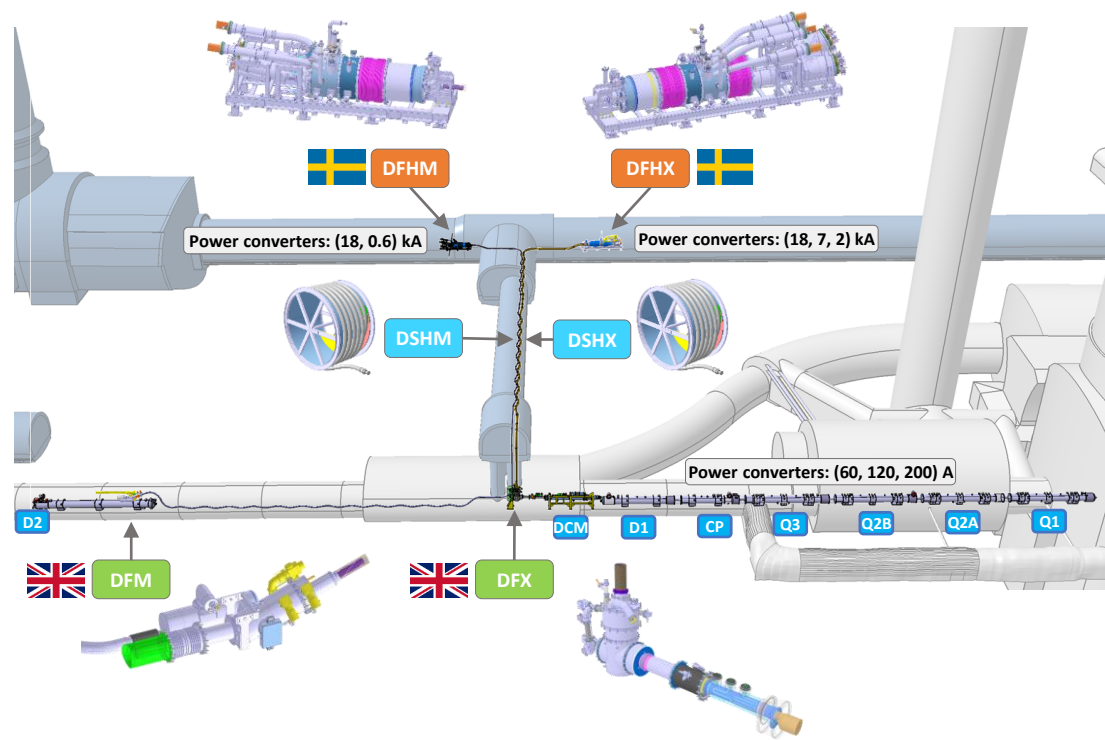
With numerous contributions from WP15, WP16, WP7, WP9, EN-MME, TE-VSC, EN-HE



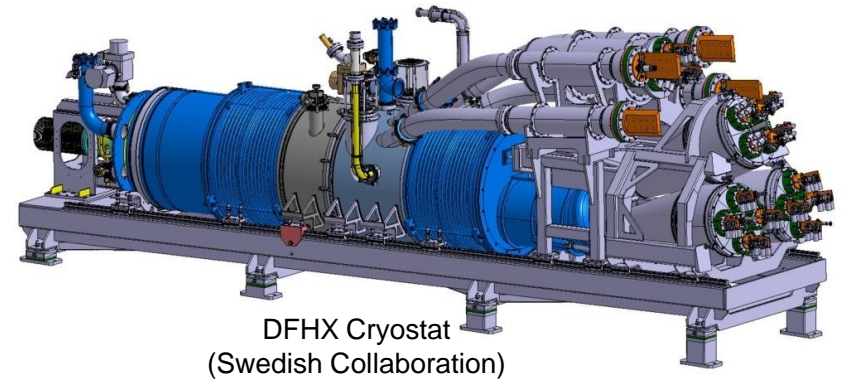
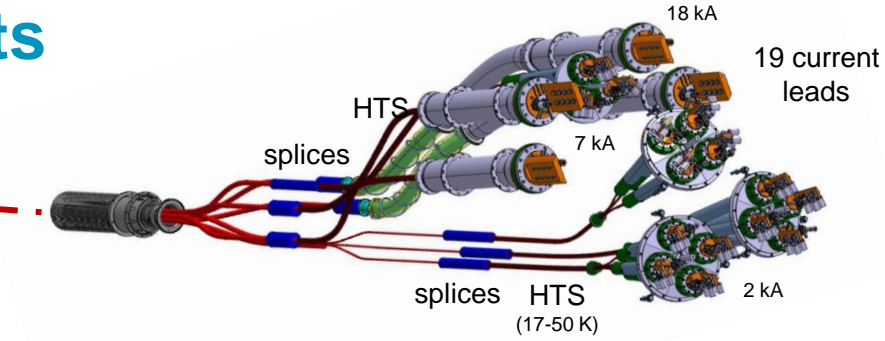
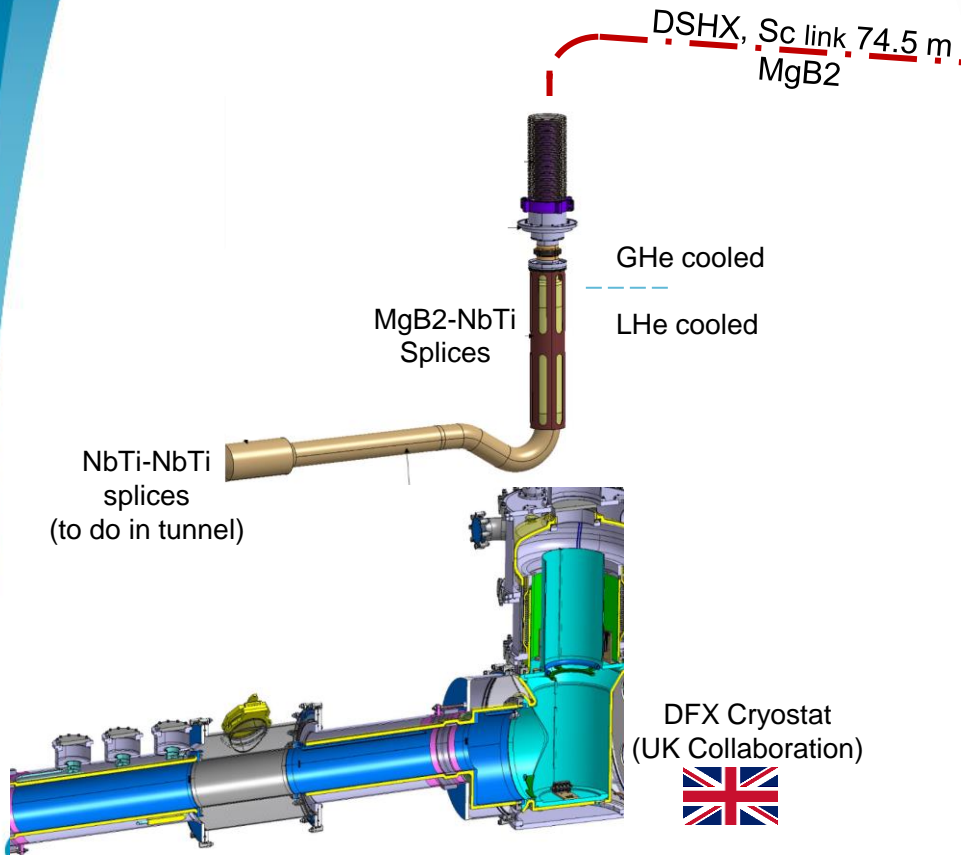
13th HL-LHC collaboration meeting – 26.09.2023

Cold Powering System (WP6a)

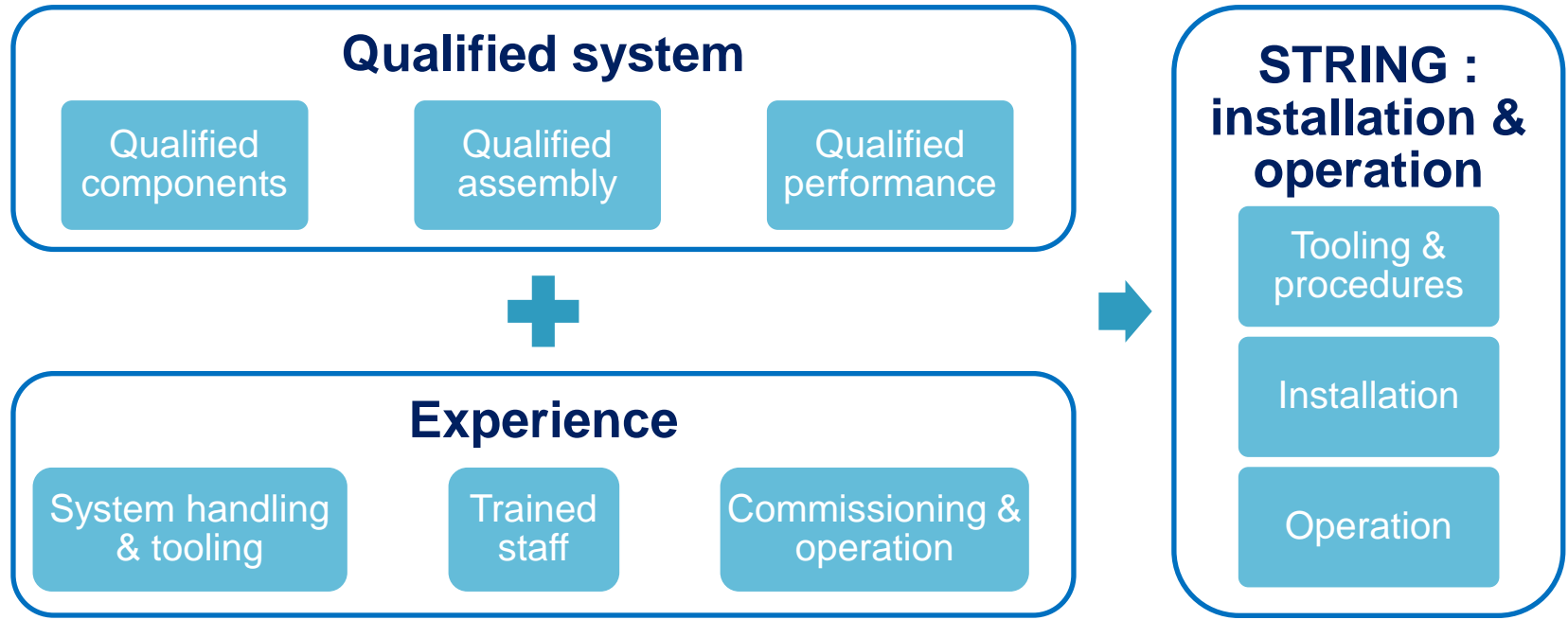
- Key function :
 - Electrical connection between magnets in the LHC tunnel and power converters in the service gallery (UR)
- 3 types of superconductors
 - NbTi / MgB₂ / REBCO
- 3 cryostats per system
- Temperature range: 1.9K to 300K
- 2 variants
 - X-type for IT : 19 branches (120 kA)
 - M-type for MS : 10 branches (50 kA)



Cold Powering for Triplets



Toward efficient and performant installation & operation in STRING



Qualified System : components

- Components procured according to European standards & HL-LHC QA
- Components qualified according to CERN approved QC procedures and acceptance criteria
- QA documentation archived in CERN database according to HL-LHC QA

DFX cryostat – CERN & Univ. of Southampton

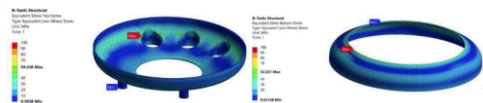
- Collaboration CERN - University of Southampton
- STRING unit, supplied by SOTON, is the first series produced at Puma engineering under UK2 by **early Oct. 2023**
- Prototype unit delivered in Q2-2022 through UK1 installed in Qualification Test Bench

Design

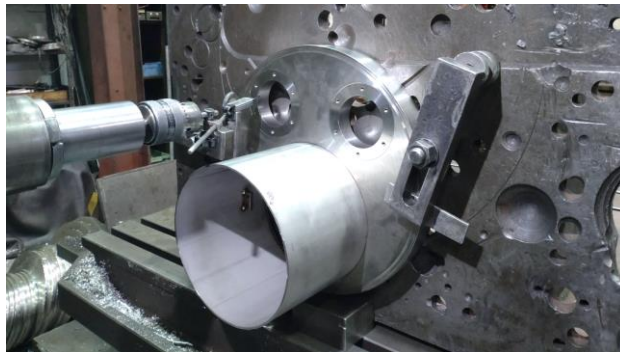
Manufacturing

Qualification

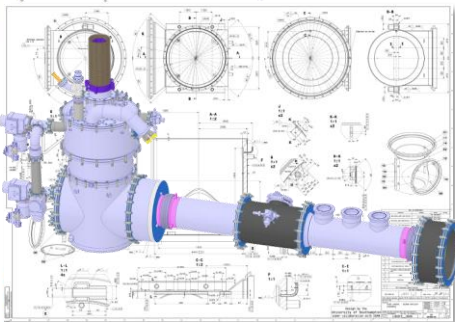
CERN-SOTON design



On-going manufacturing of DFX STRING unit at Puma Engineering, followed-up by the University of Southampton



Prototype unit for illustration supplied by University of Southampton. Delivered CE stamped and QC



DFHX cryostat – CERN-Uppsala collaboration

- DFHX unit installed in STRING was manufactured at CERN & RFR Solutions (SE) and was the support of significant knowledge transfer. Delivery completed in 2022
- Series DFHX (x4) and DFHM (x5) cryostats to be delivered through CERN-Uppsala collaboration. Manufacturing shared between Uppsala University & RFR Solutions

Design

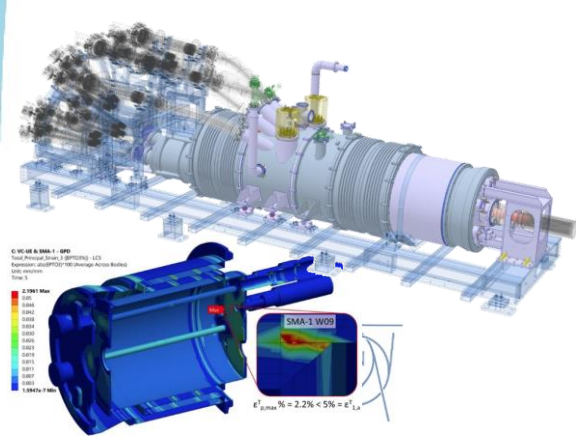


Manufacturing



Qualification

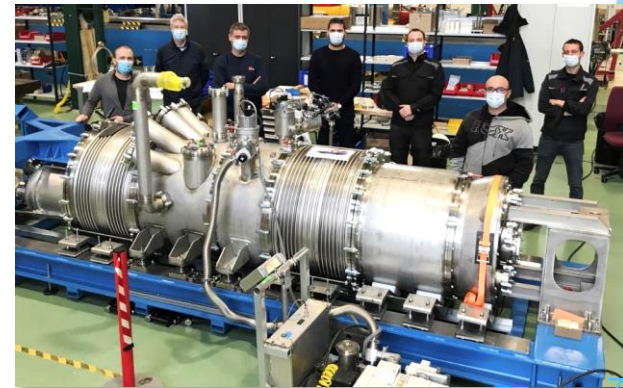
CERN design



Manufacturing of DFHX prototype unit at CERN & RFR solutions



Prototype unit during QC phase @ CERN



Readiness of other components used in STRING

- MgB_2 Cable delivered in Q1-2021
- 75 m long flexible cryostat : delivered Q2-2022 from Cryoworld (NL)
- 19 Current leads assembled with HTS cable at CERN : August 2023
- QC process qualified at the suppliers or/and tested at reception at CERN

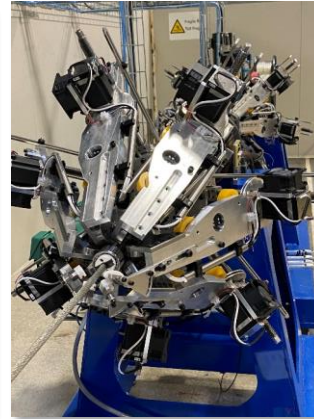
MgB₂ cables at CERN



19 Current Leads



HTS cabling machine

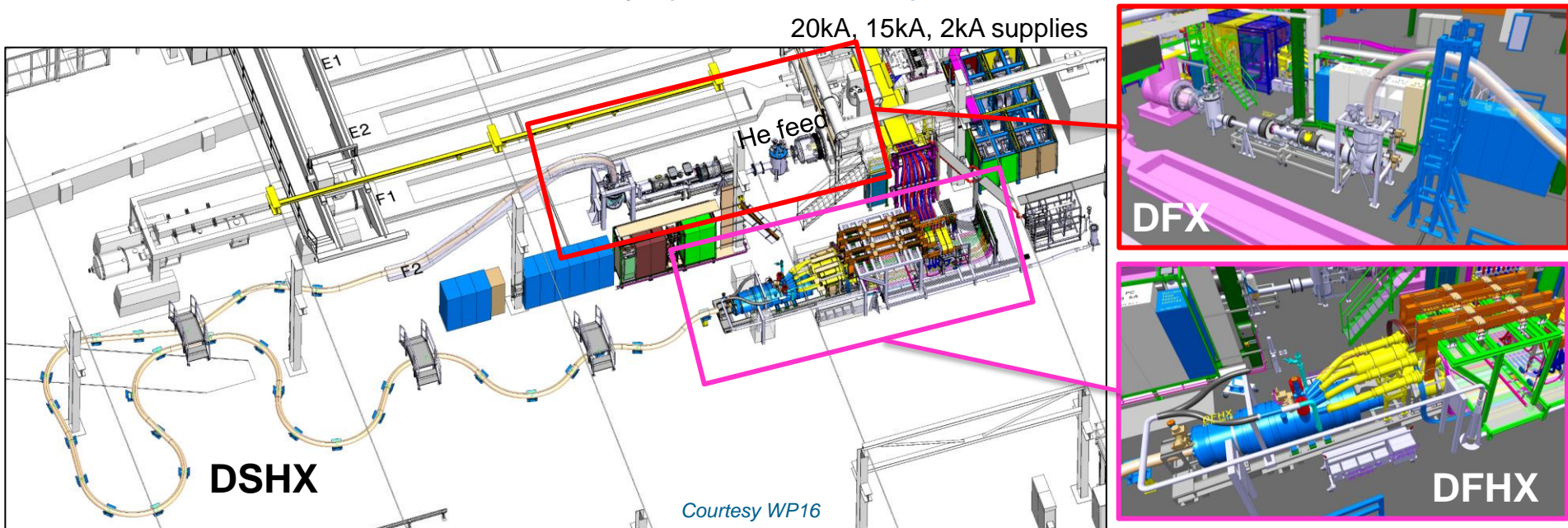


DSHX – QC procedure qualification



Qualified System : Assembly

- The Cold Powering System installed in STRING is tested at F2 bench in SM18 facility
 - Qualification of system
 - Acquire **experience** for efficient tooling design & procedures
 - Acquire experience in Cold Powering System **handling**
 - Validate **interfaces** and assembly operation **to be repeated** in STRING



Qualified System : Assembly

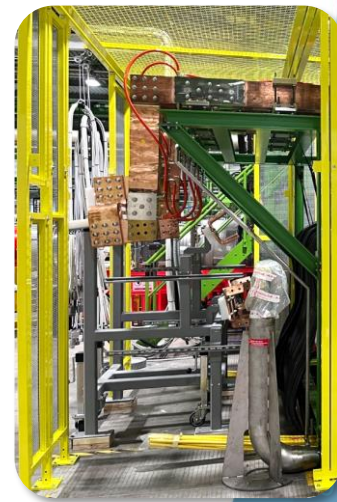
MgB2
cable
insertion

DFHX
assembly

Current
Leads
assembly

SCLink
DFX
assembly

Interfaces
connection
& QC





DFX assembly & Final QC

Qualified System : Experience for STRING

Cryostat **Spooling** & Unspooling

- Parameters fine tuning
- Speed, torque, flexibility, **margins**...

SCLink handling

- **Spring back** quantification
- Manual handling and **limits**
- **Flexibility** quantification and limits
- Procedure to ensure **bending radius** respect
- **Optimized** tooling...

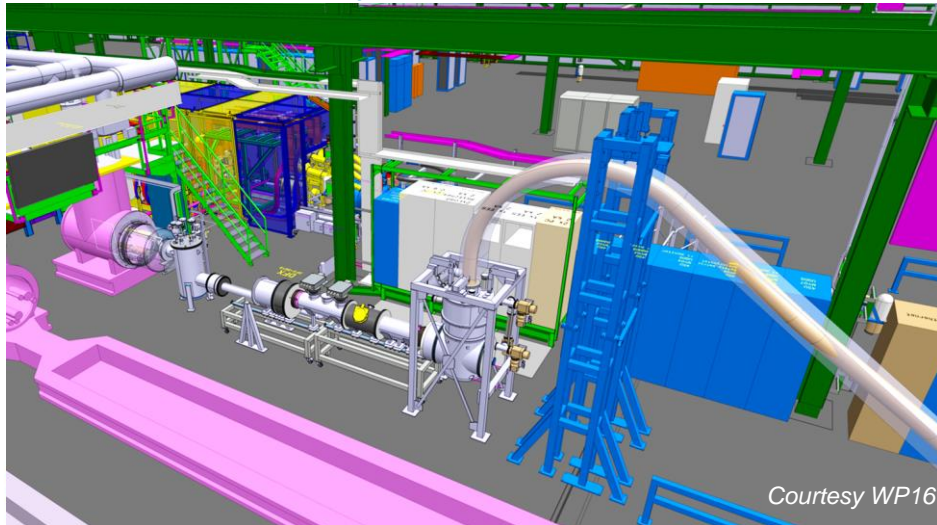
Qualified System : Experience

- SCLink insertion into DFX
 - Same operation & similar tooling in STRING
 - Same weld adjustment (0.3mm)
 - 3 months : tooling fine tuning & staff training



SCLink-DFX interface : dedicated mock-up for practice

DFX integration @ F2 test bench



Courtesy WP16

SCLink insertion operation : practice

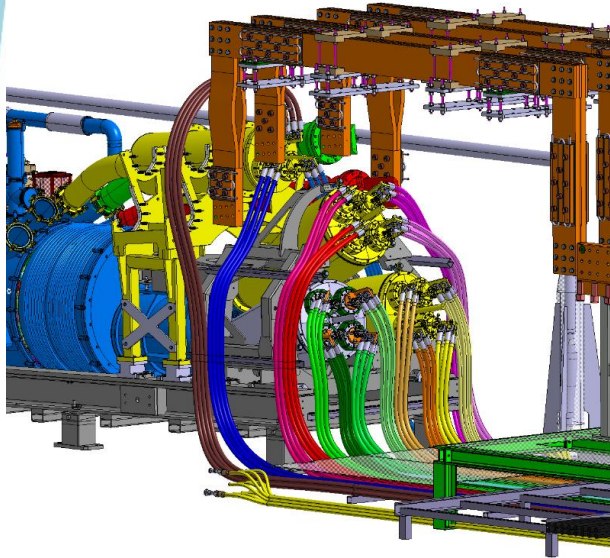


Qualified System : Experience for STRING

Current Leads Electrical connections

- Same operation, same connection layout & same pre-cabling tooling in STRING
- Cabling procedure, tool qualification & staff training

DFHX interface integration



Electrical test tool



DFHX services interface @ F2 bench

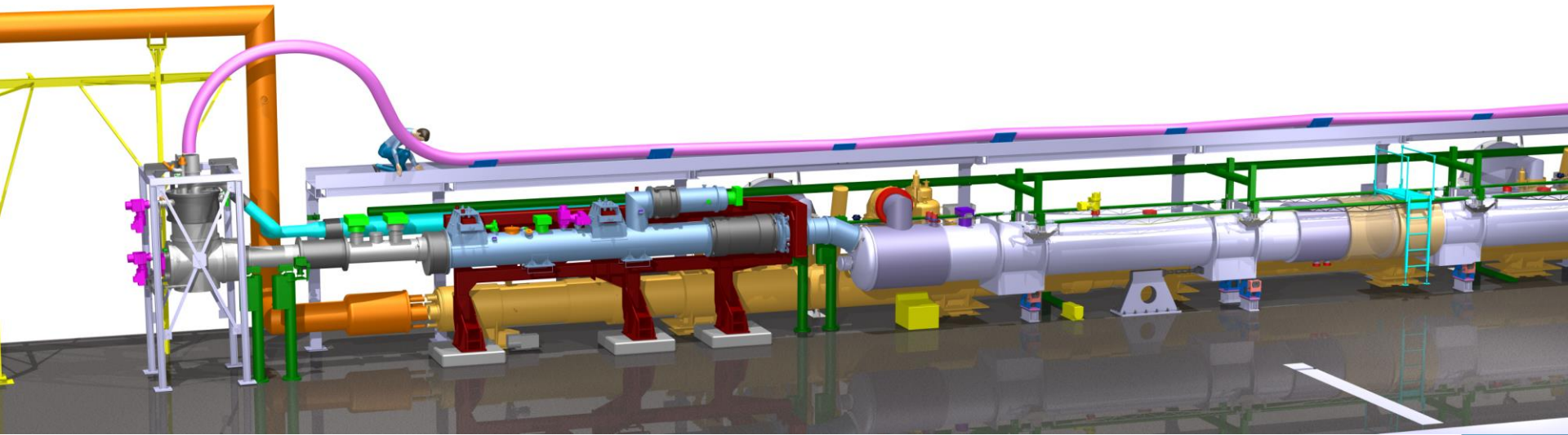


Qualified System : Operation

- Thermal performance
 - Temperature **distribution** in cryostats & splices
 - Validation of static and dynamic **heat loads**
 - Cool down/warm up control and **response time**
- Electrical performance
 - Circuit characteristics for the 19 branches

Installation in STRING

- Completion of procedures and tooling : Q4-2023
- Installation of qualified Cold Powering System from January 2024

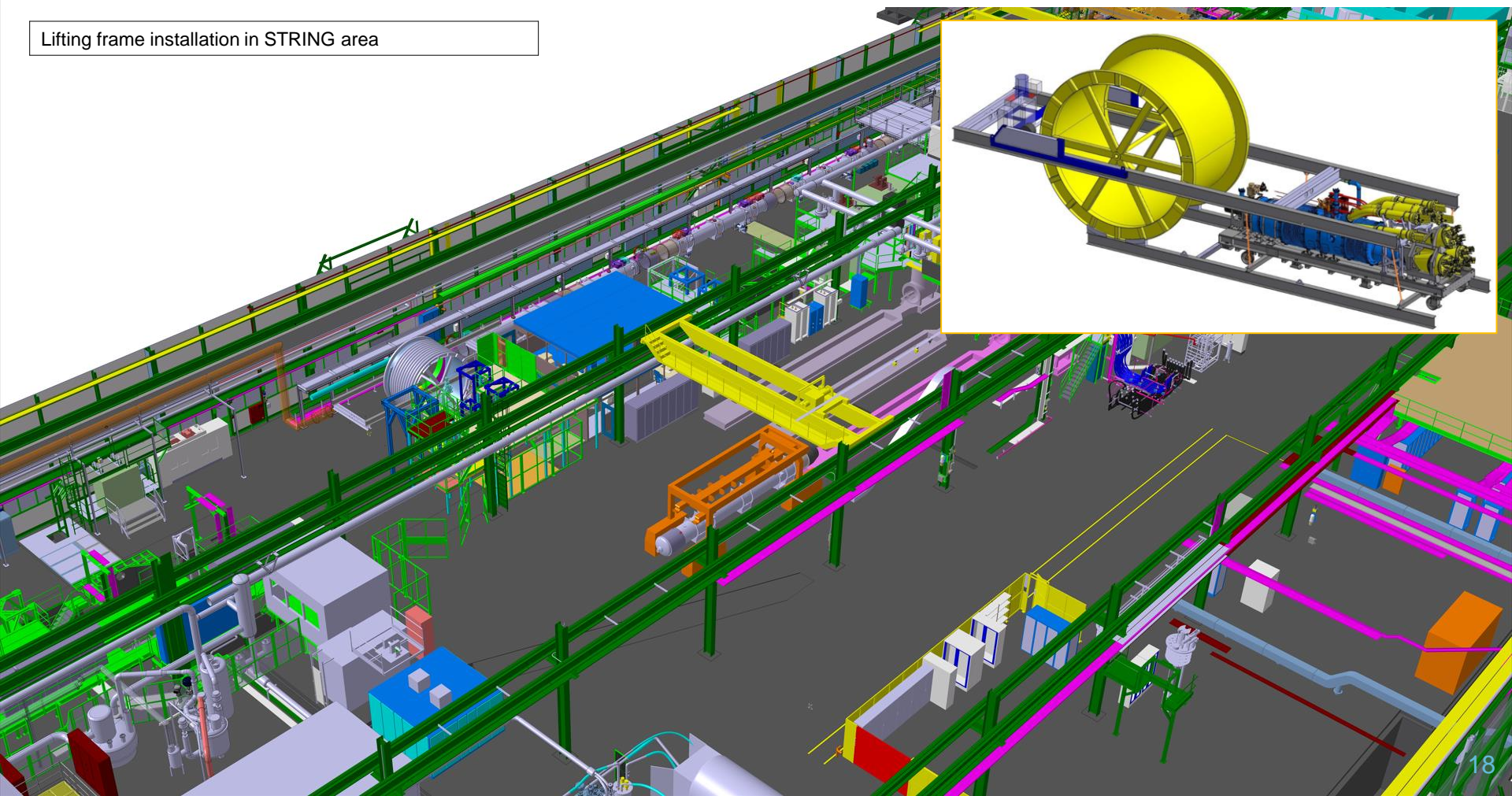


Cold powering assembly sequence at IT String

by **Stefanos Christos Spathopoulos, TE-MS-CMI**
(using WP16 integration models)

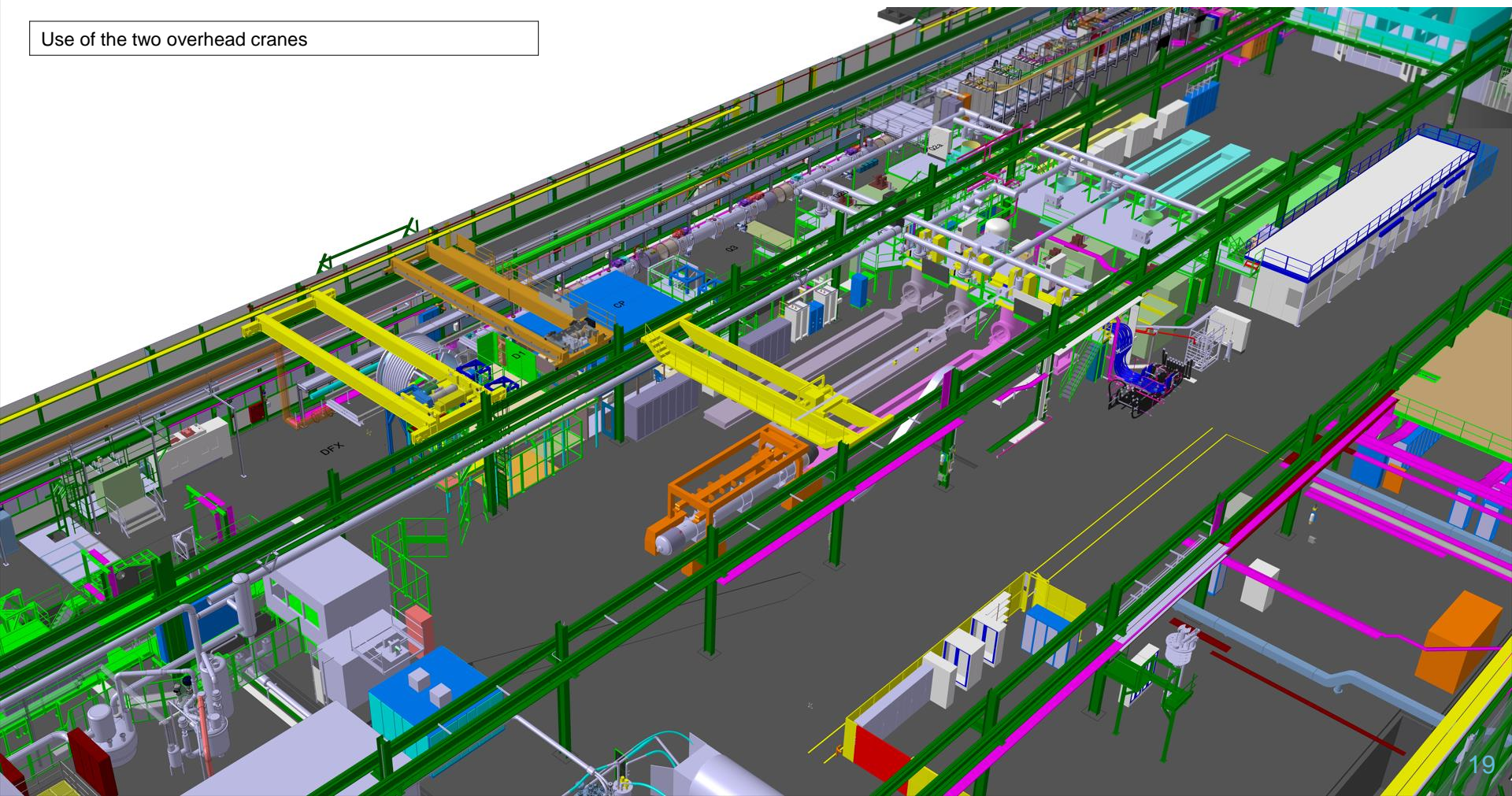
Phase 1: DFHx-SCLink subassembly lifting and installation on the platform

Lifting frame installation in STRING area



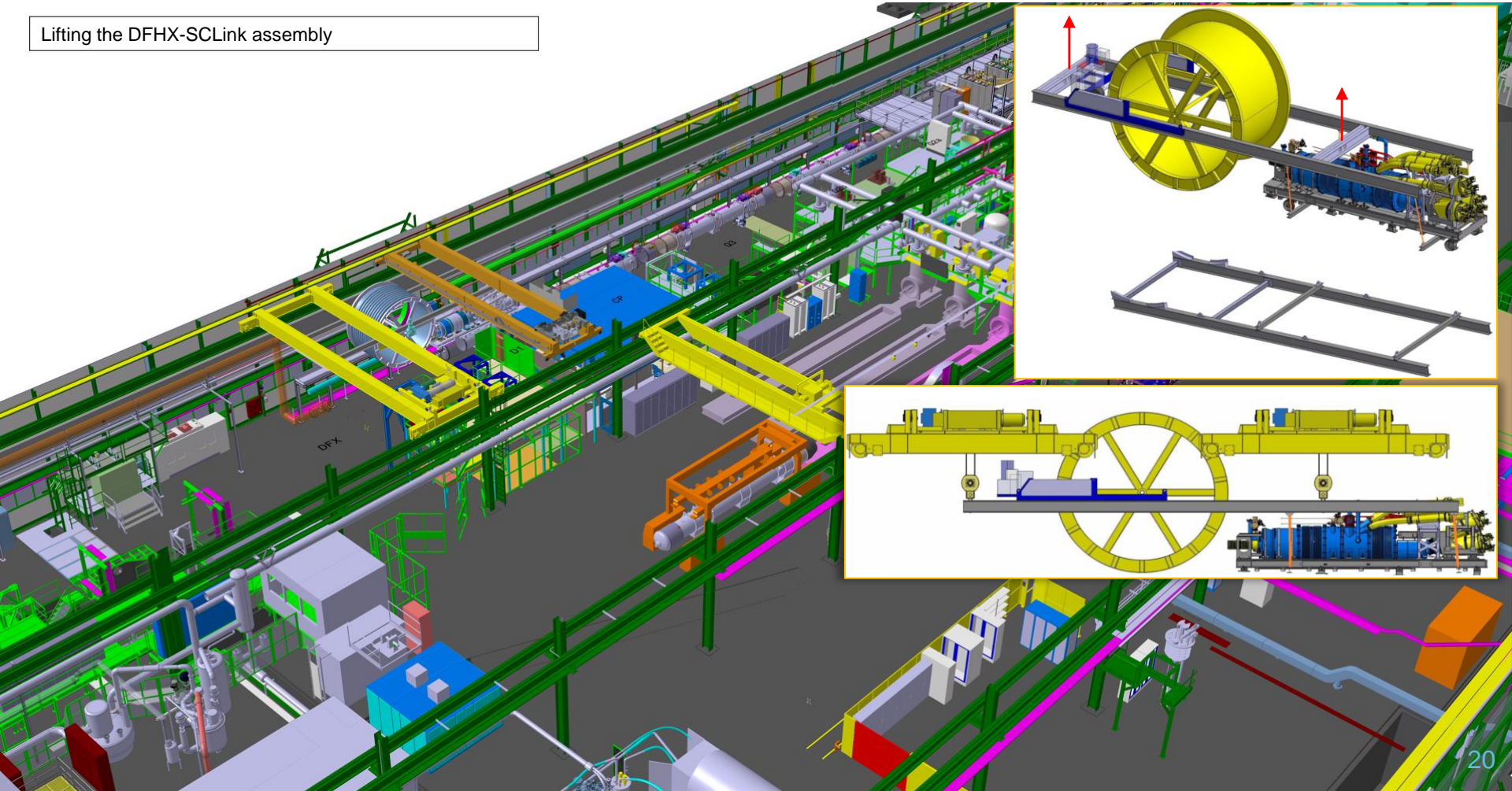
Phase 1: DFHx-SCLink subassembly lifting and installation on the platform

Use of the two overhead cranes



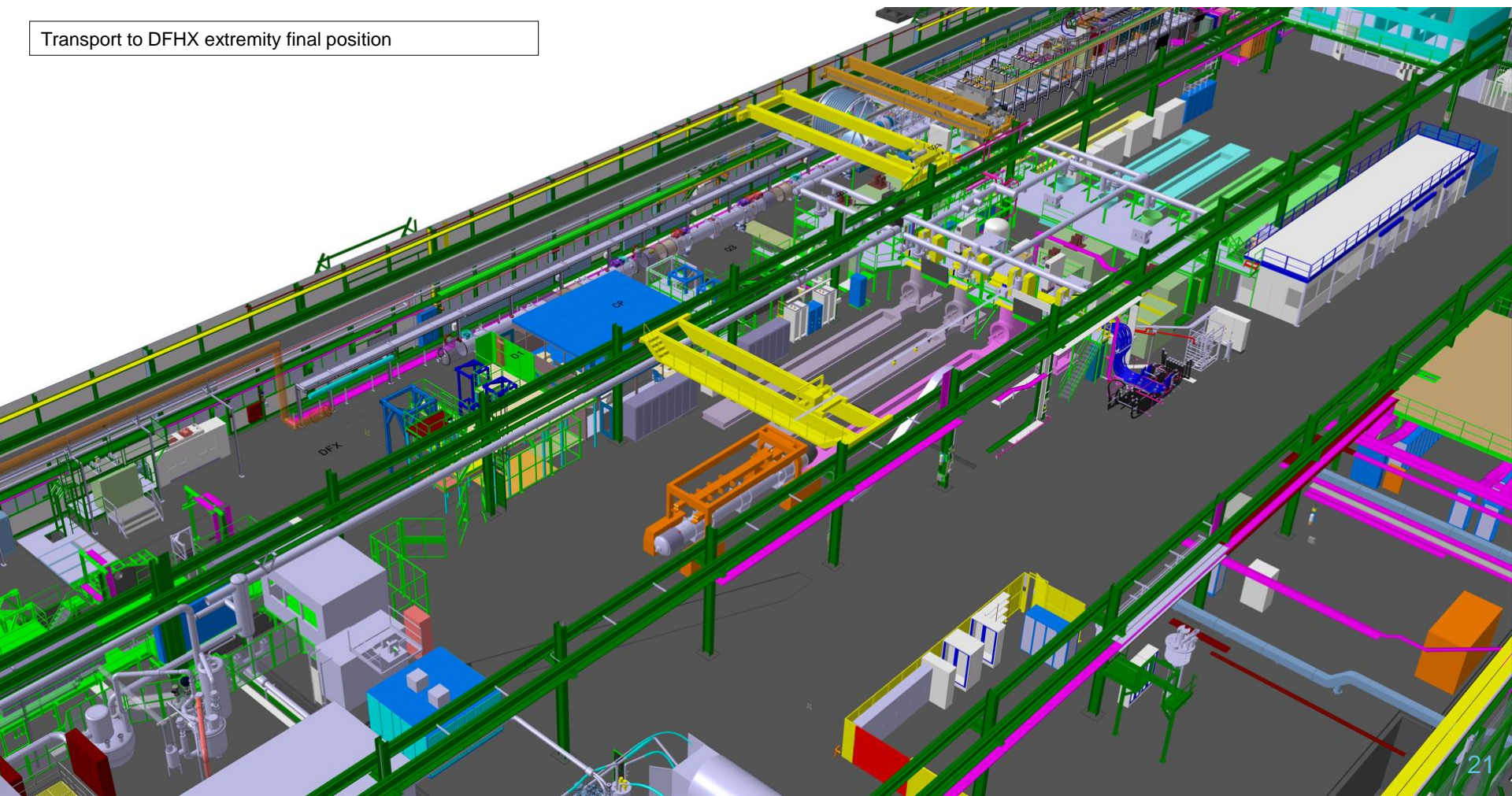
Phase 1: DFHX-SCLink subassembly lifting and installation on the platform

Lifting the DFHX-SCLink assembly

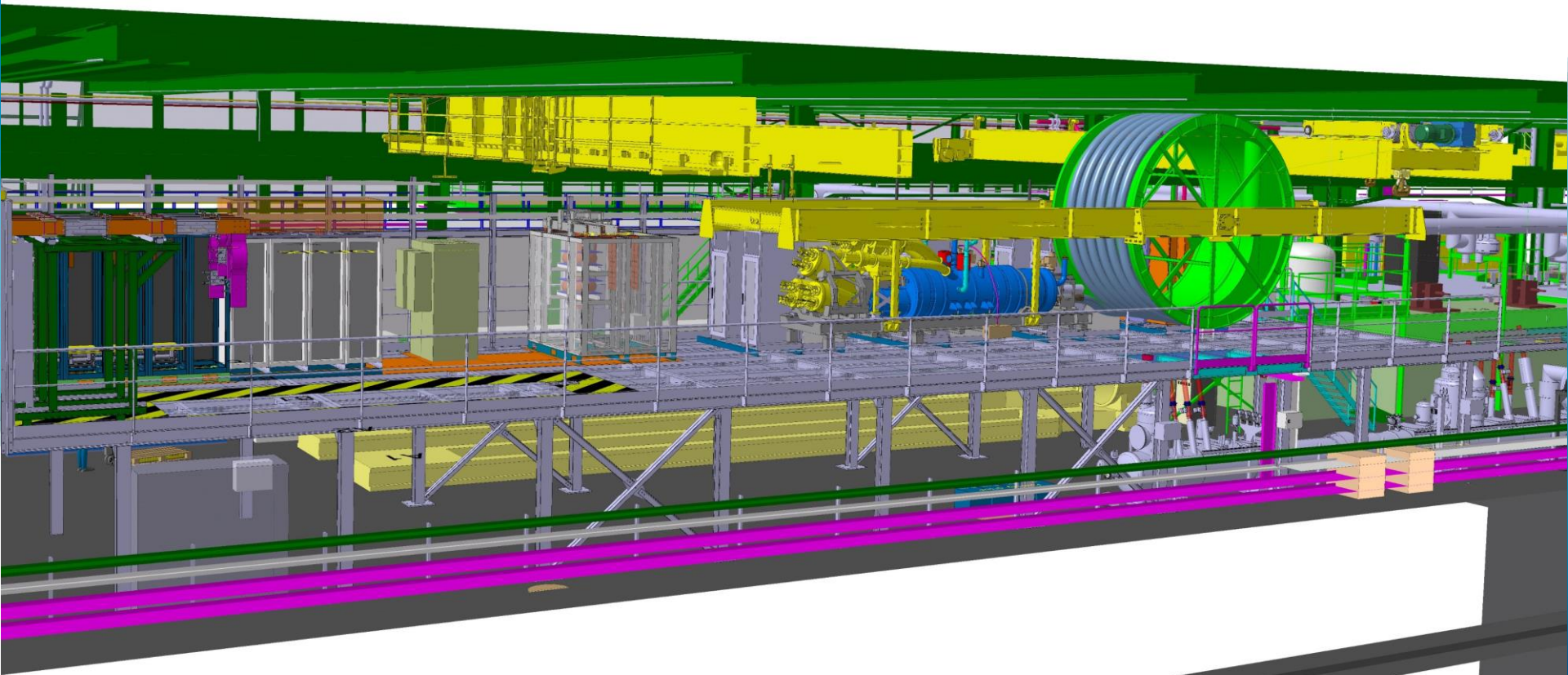


Phase 1: DFHX-SCLink subassembly lifting and installation on the platform

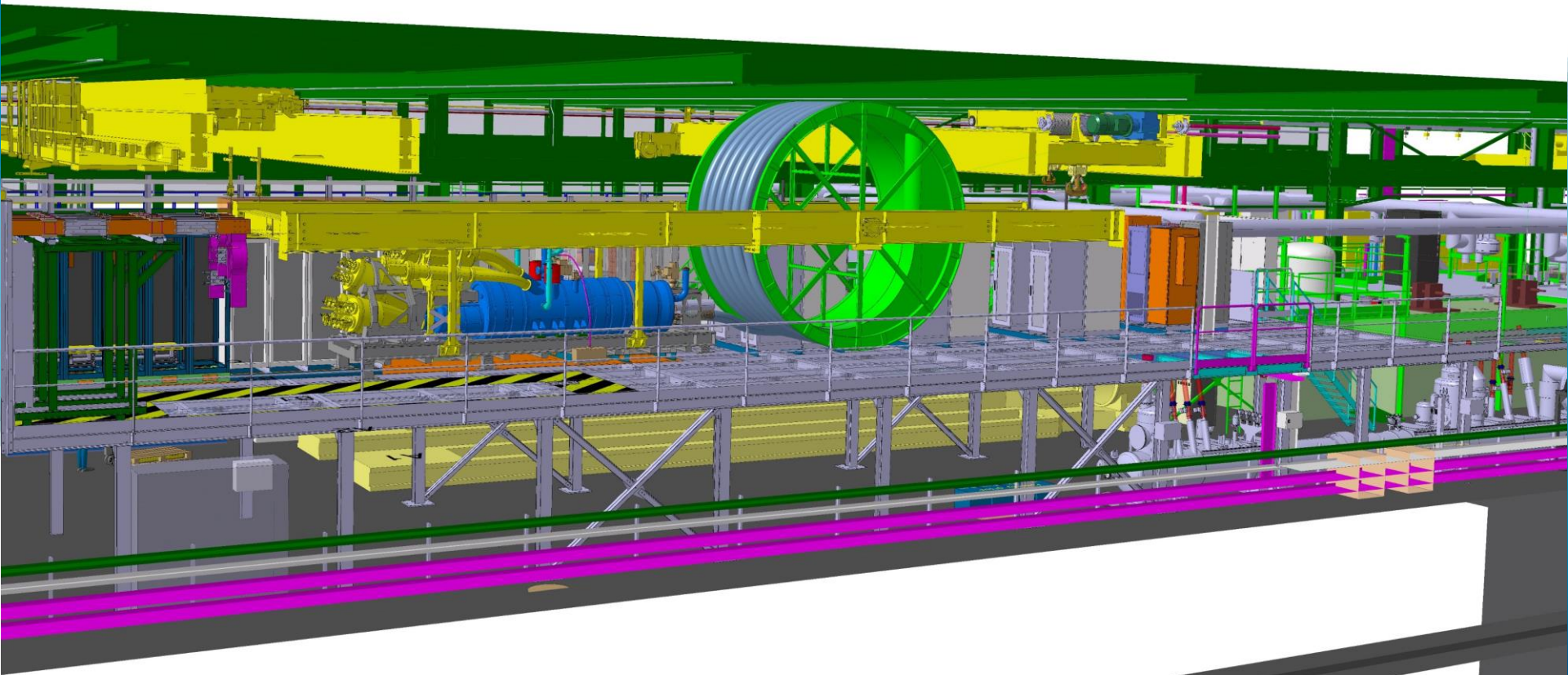
Transport to DFHX extremity final position



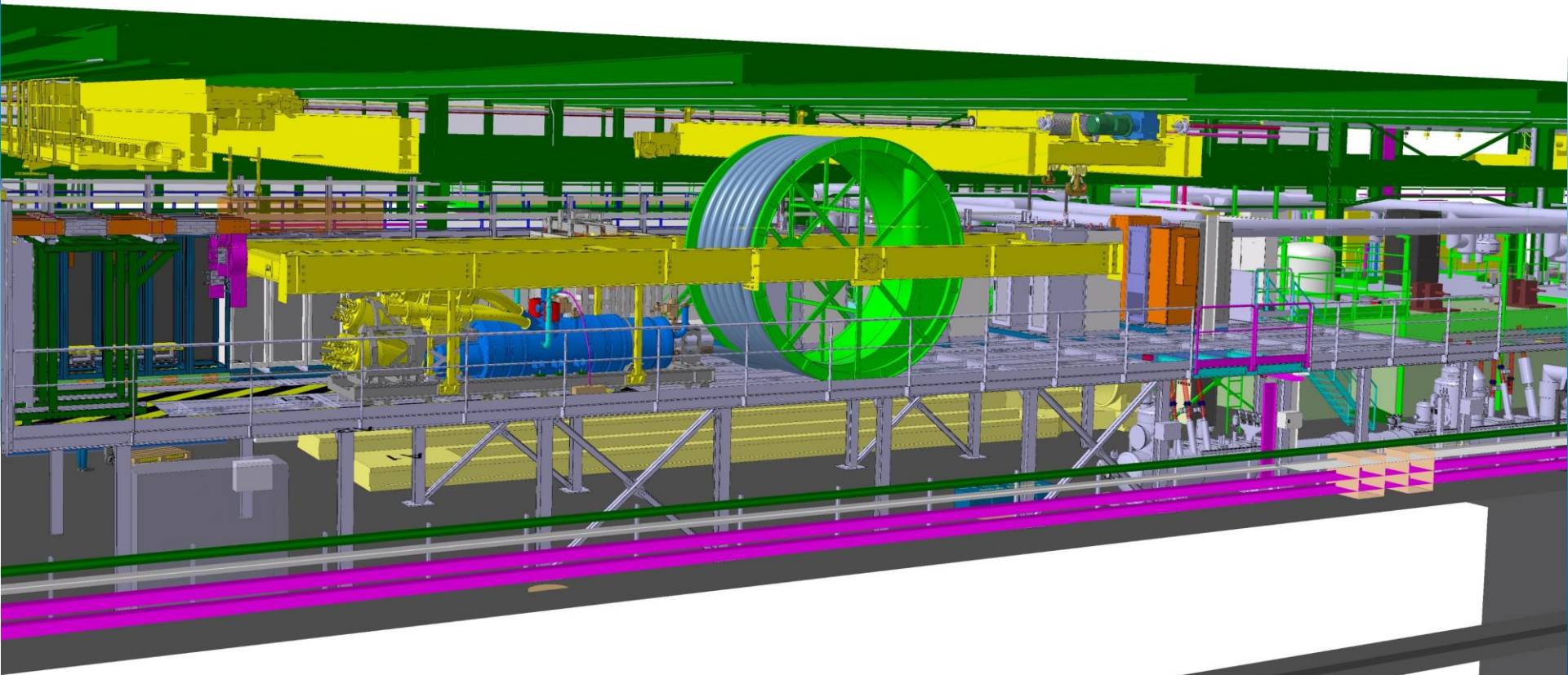
Position the DFHX in lateral final position



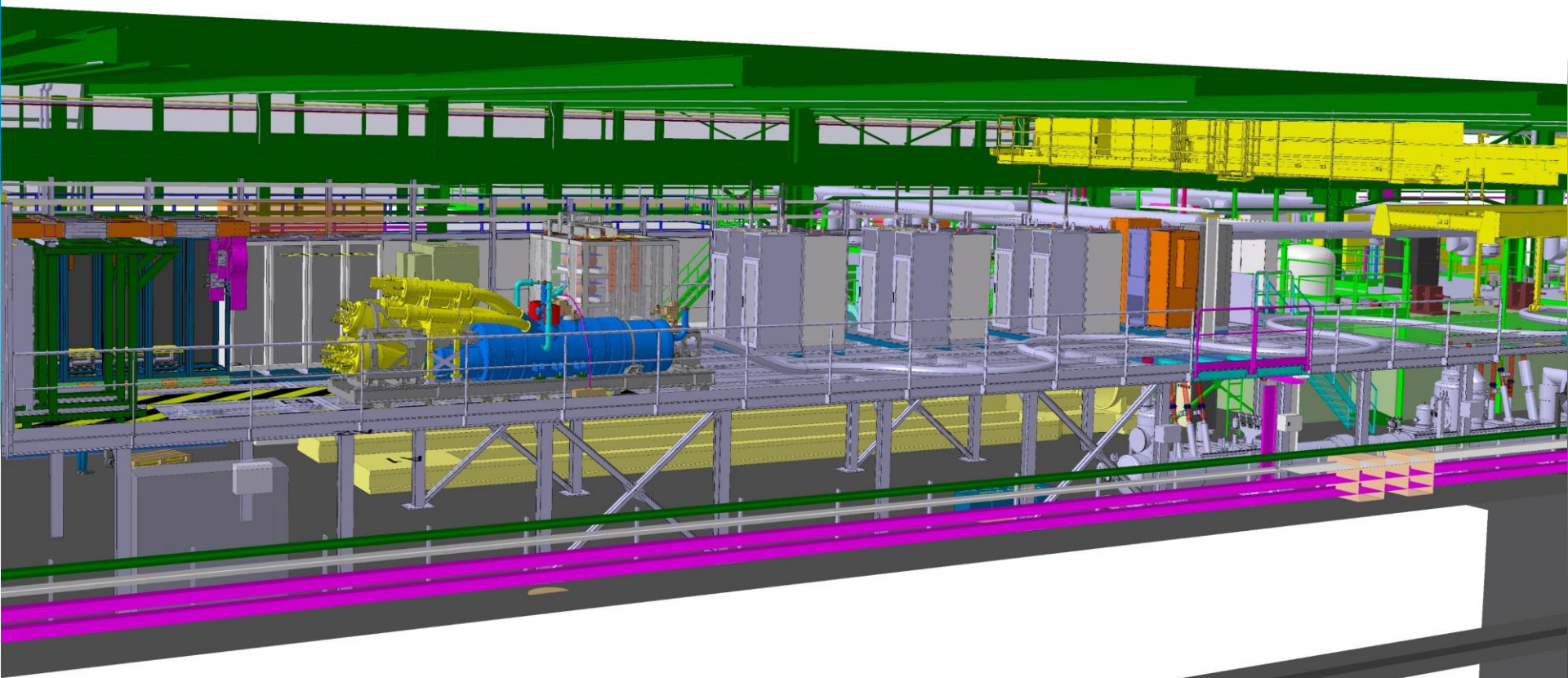
Stop in plane displacement



Lower the DFHX+SCLink assembly

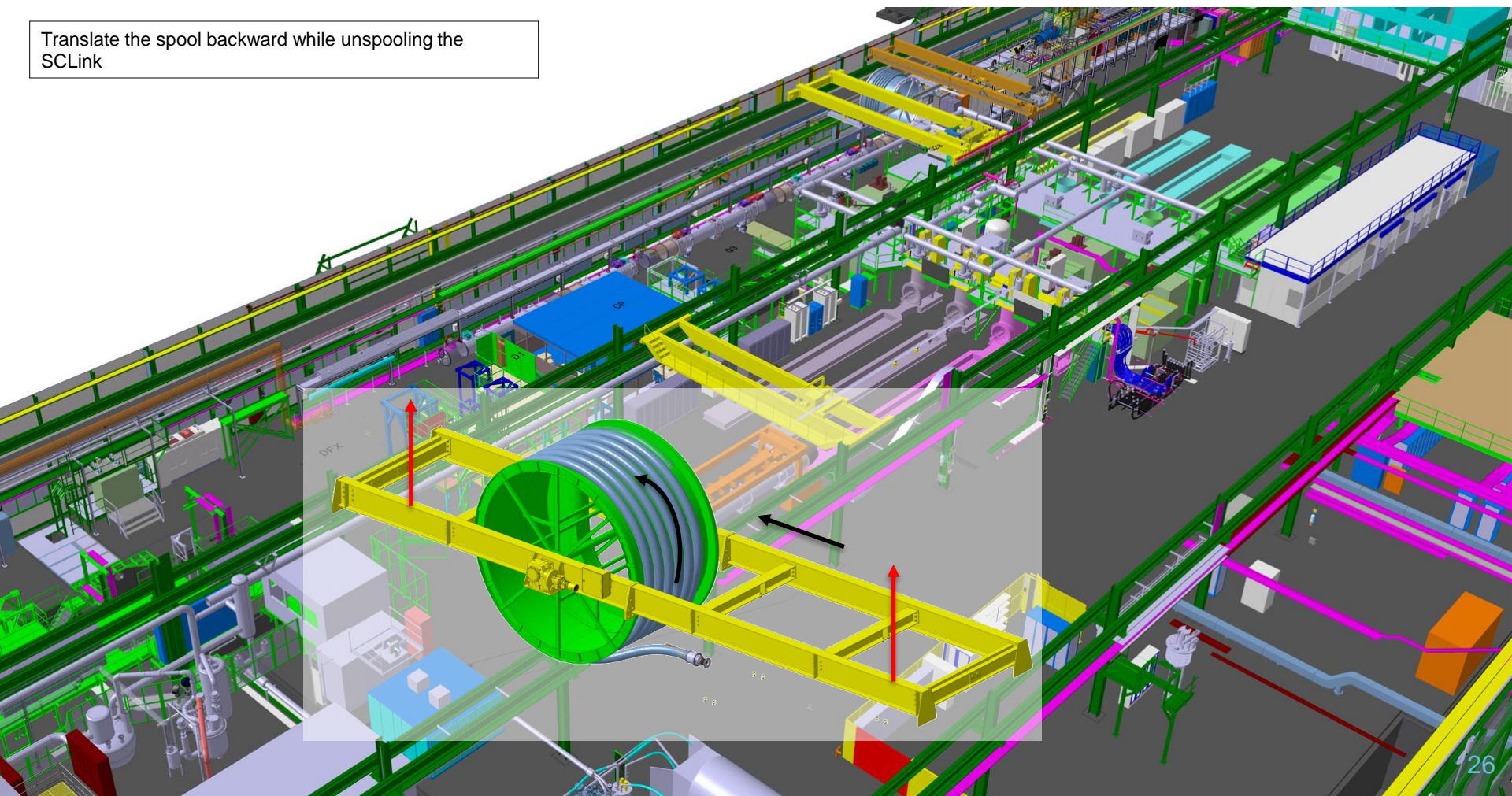


Disconnect and remove the lifting frame tool



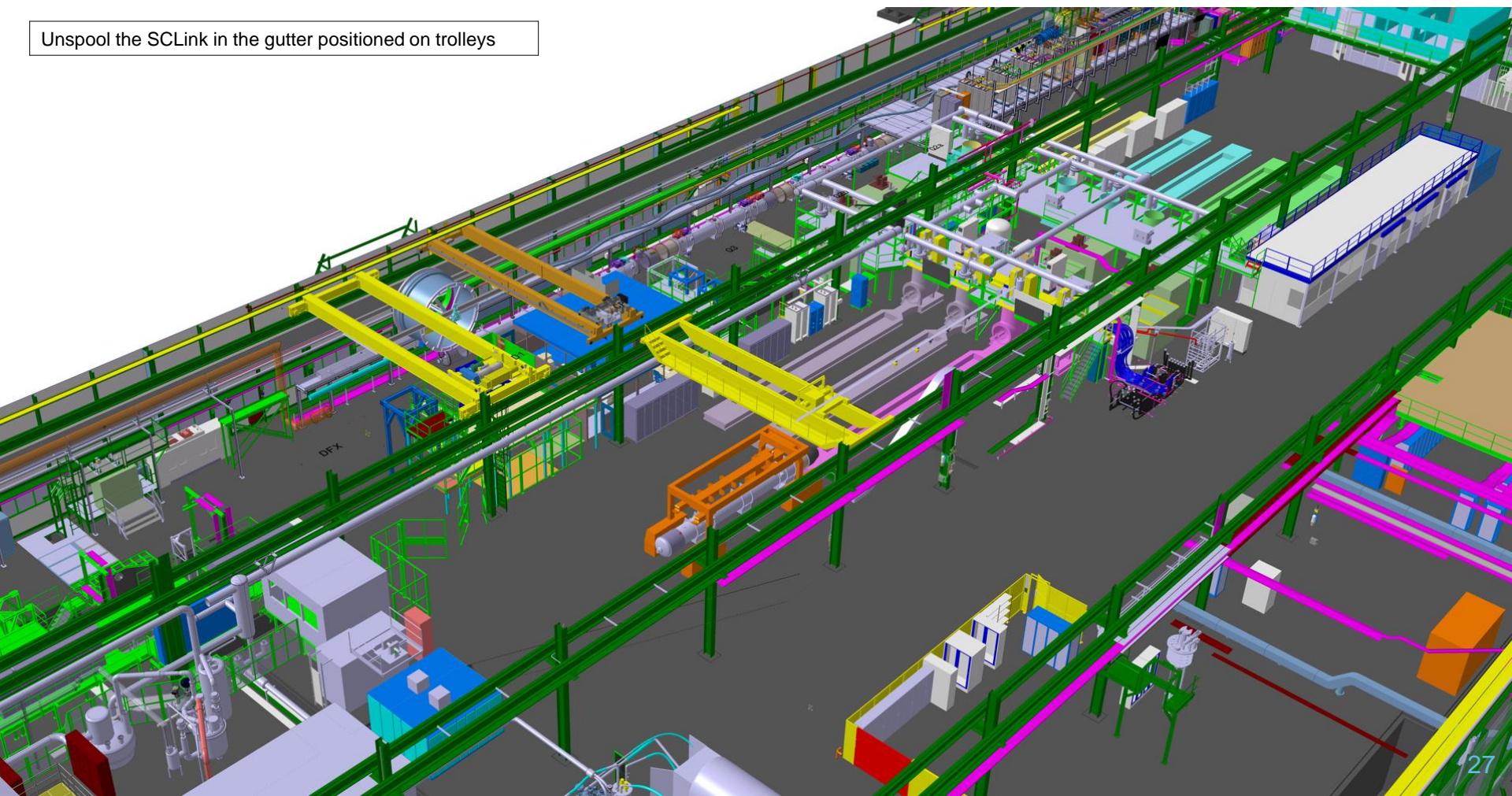
Phase 2: SCLink unrolling

Translate the spool backward while unspooling the SCLink



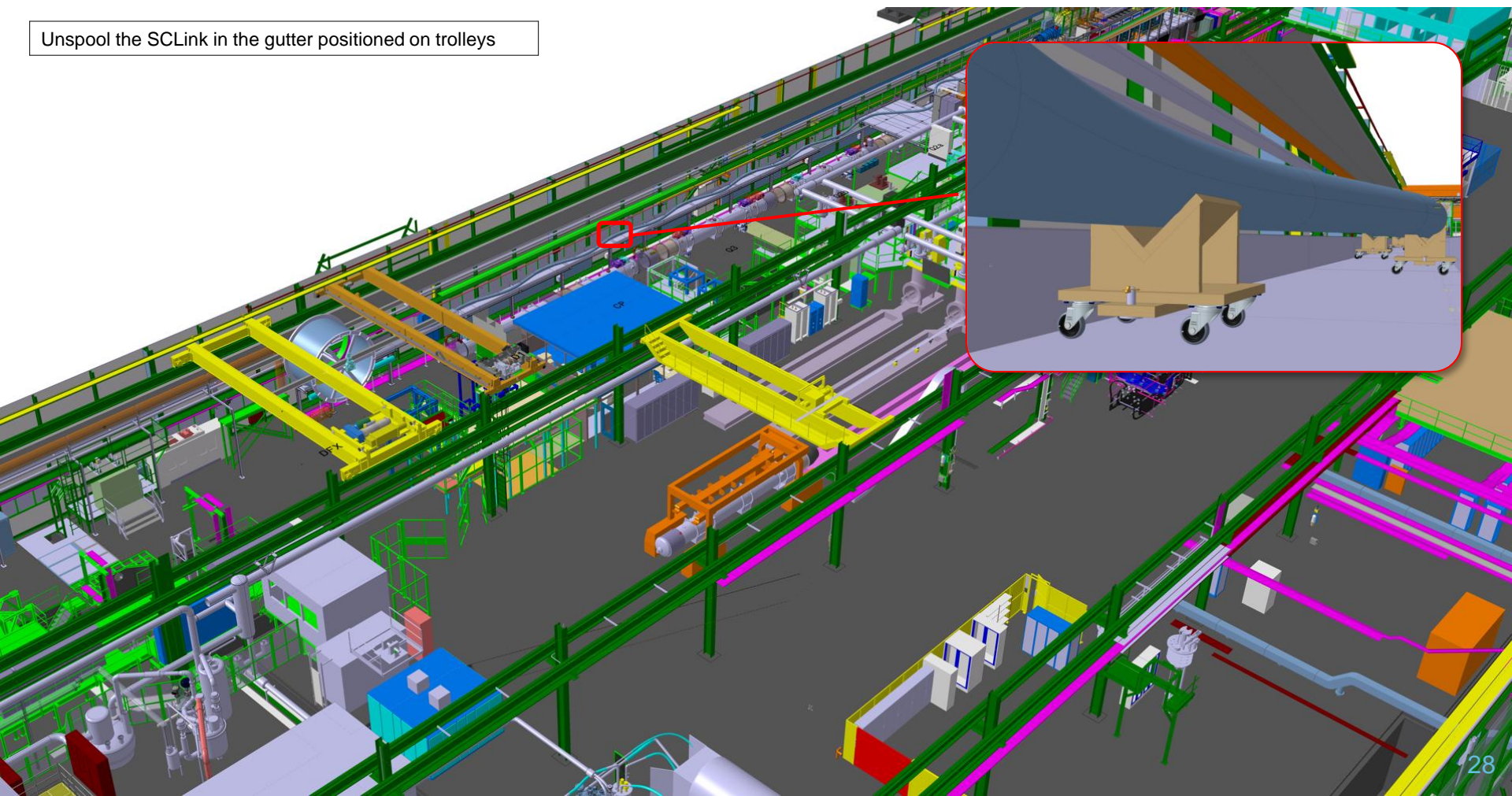
Phase 2: SCLink unrolling

Unspool the SCLink in the gutter positioned on trolleys



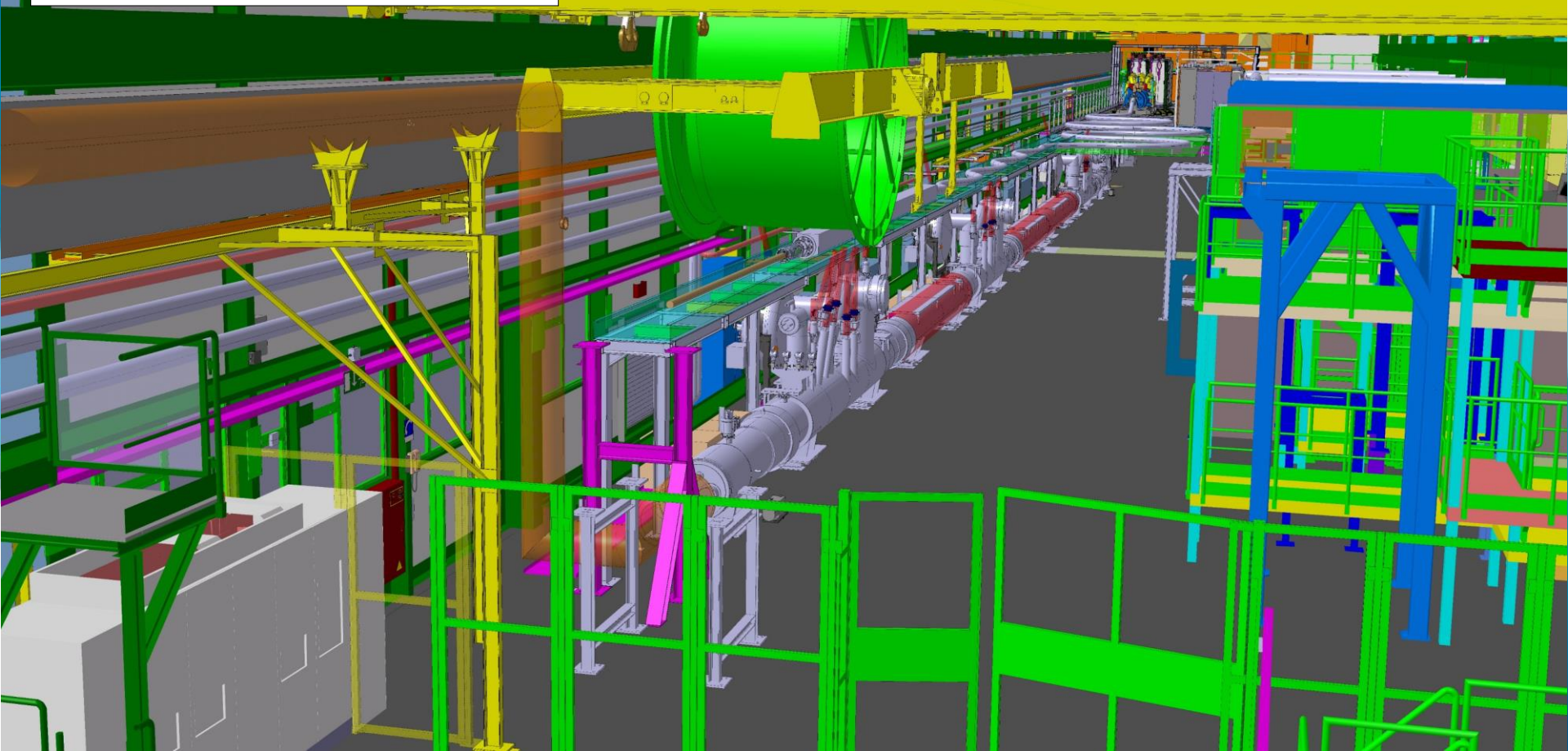
Phase 2: SCLink unrolling

Unspool the SCLink in the gutter positioned on trolleys

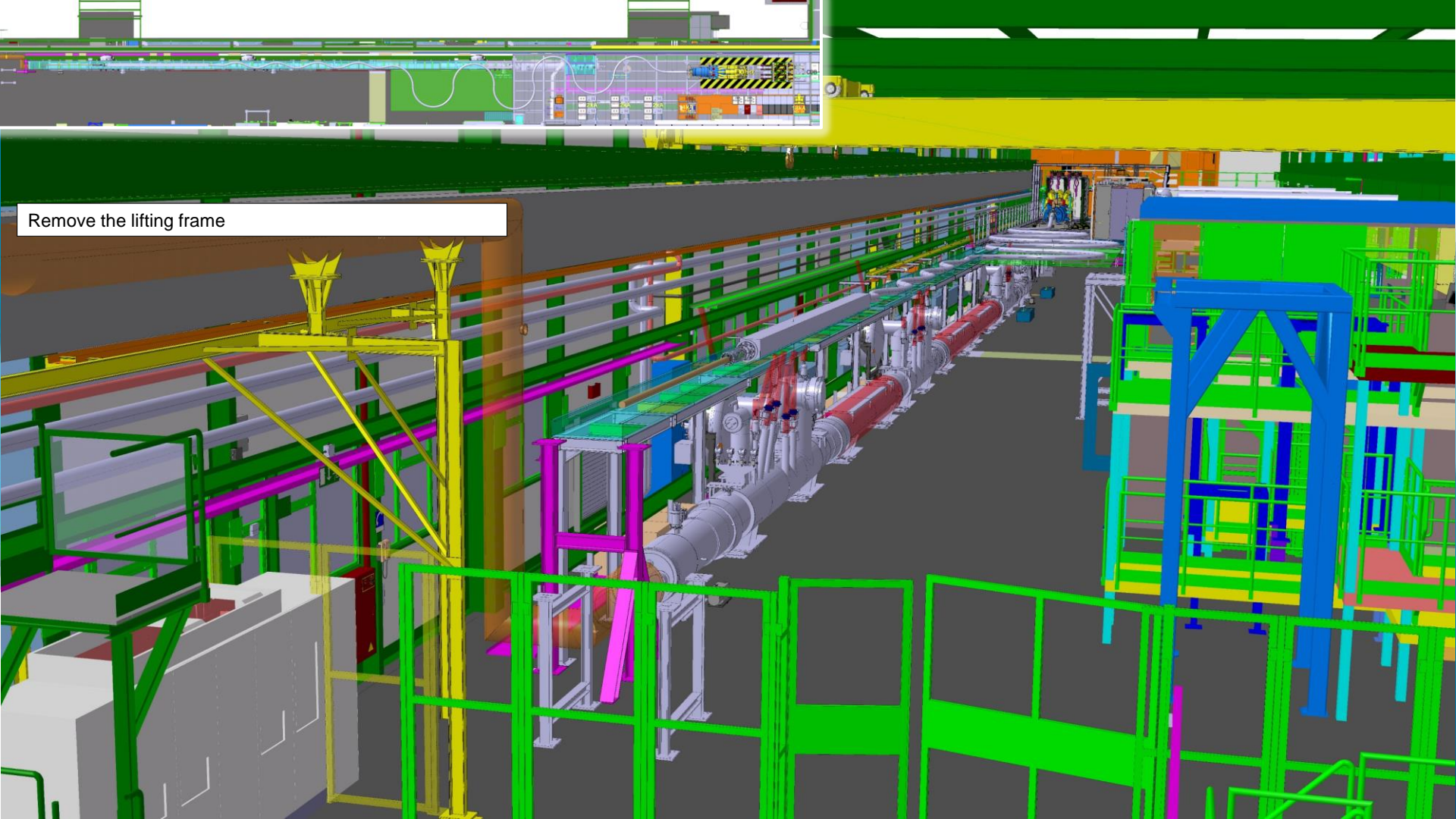


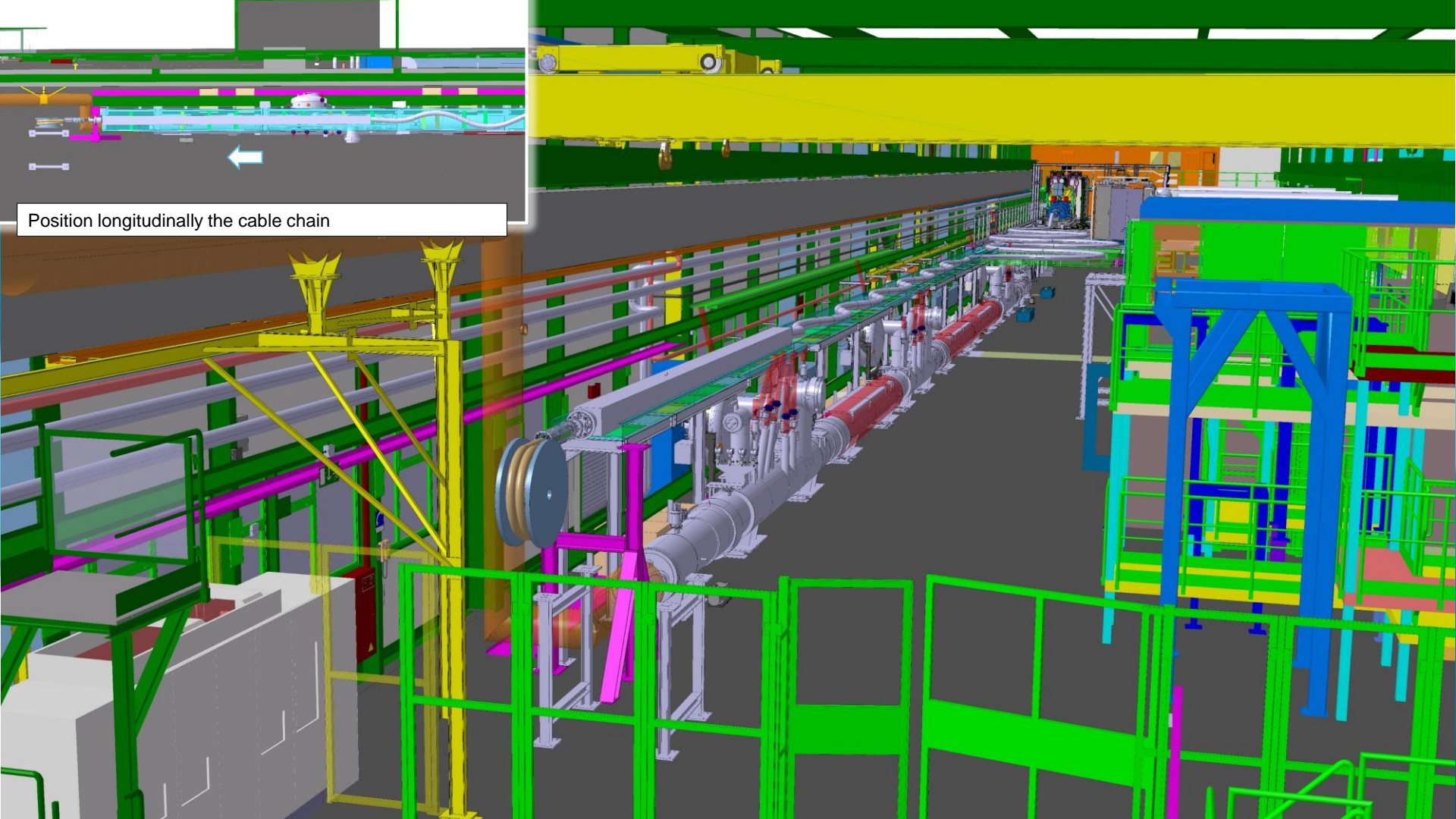
Phase 3: DFX assembly

Unspool the SCLink with its NbTi extension in the cable chain

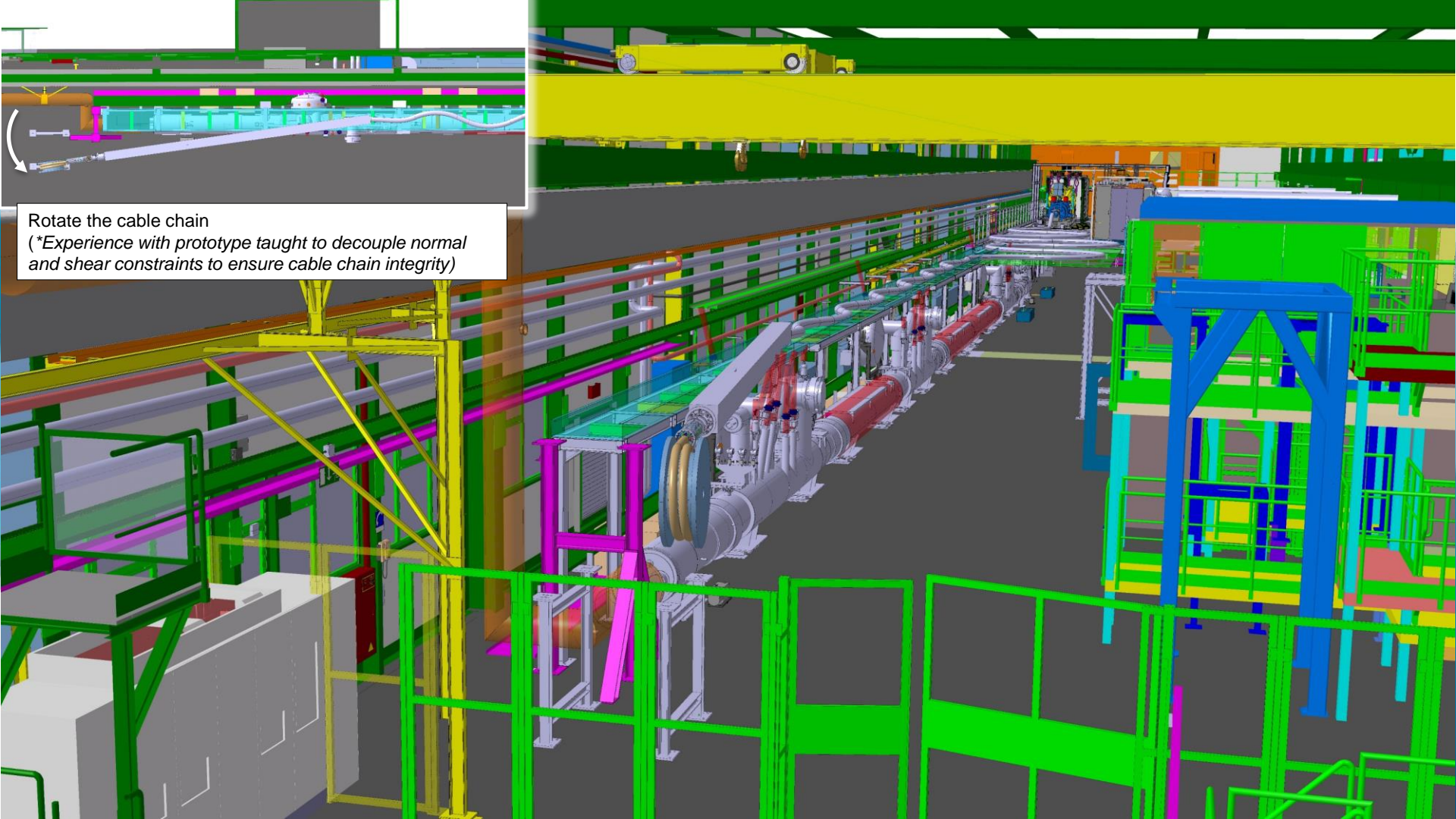


Remove the lifting frame



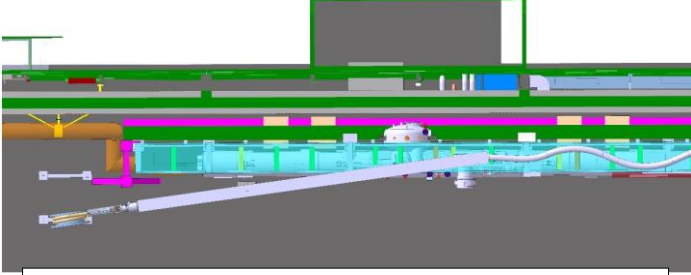


Position longitudinally the cable chain

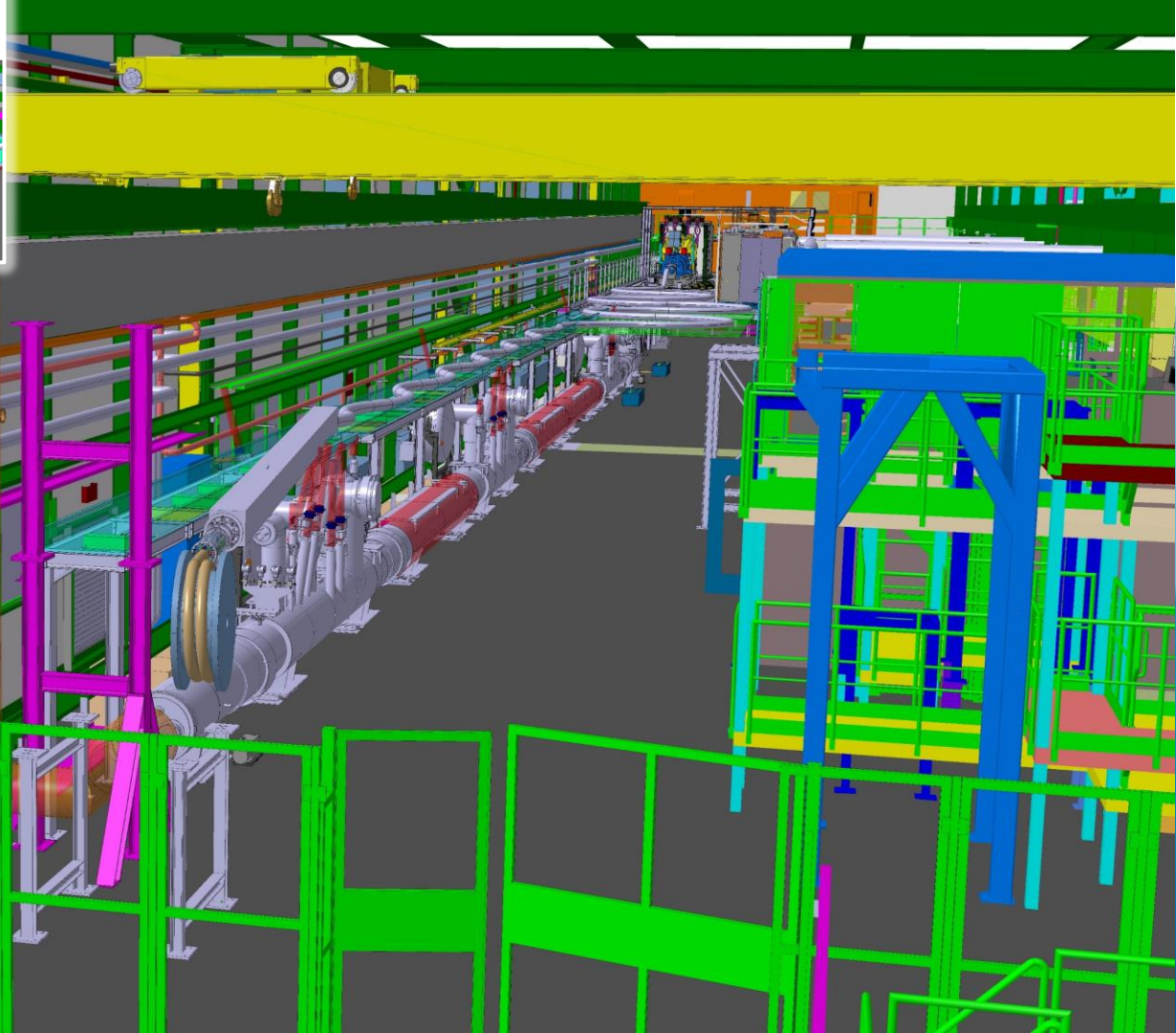


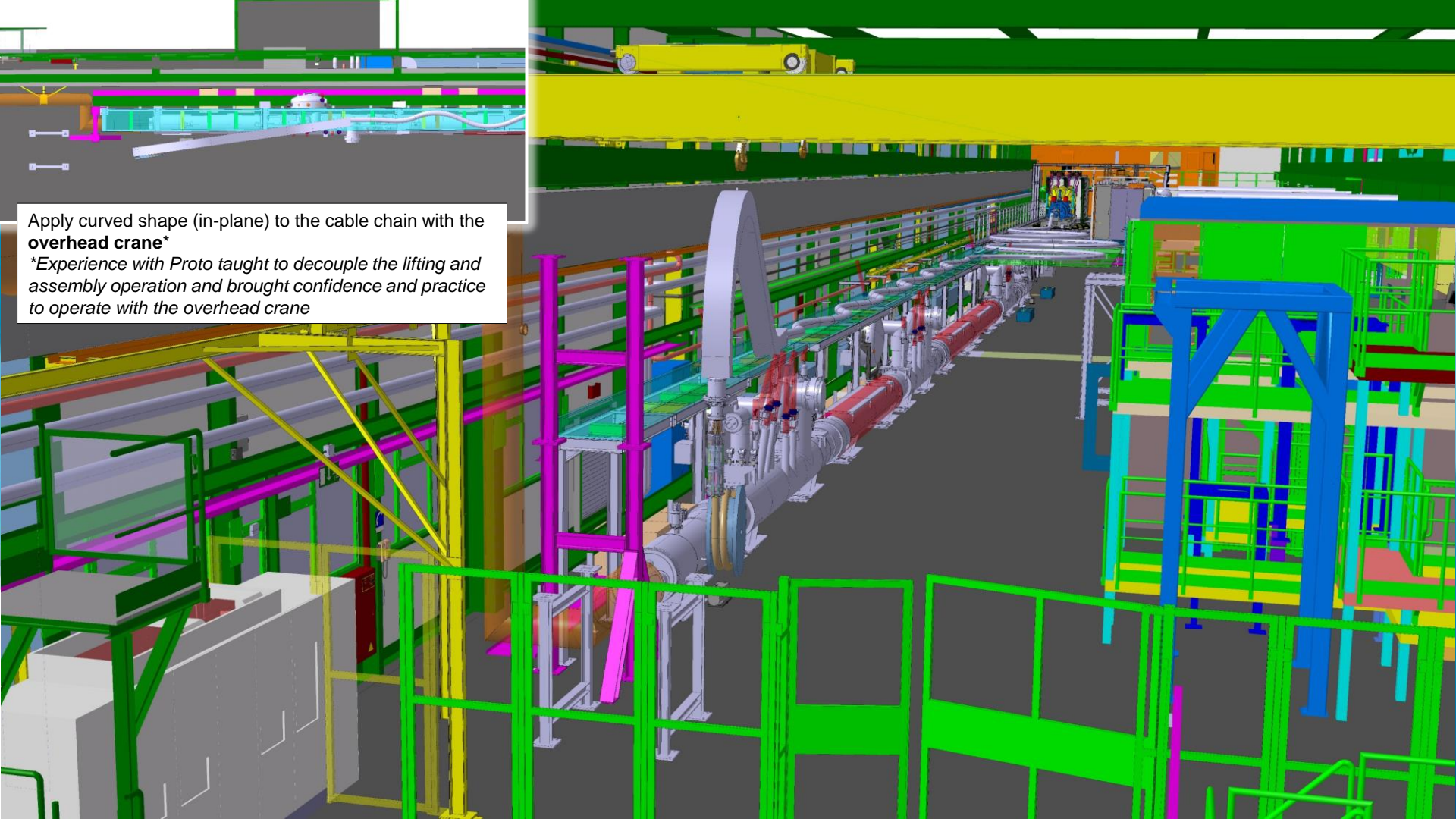
Rotate the cable chain

(*Experience with prototype taught to decouple normal and shear constraints to ensure cable chain integrity)



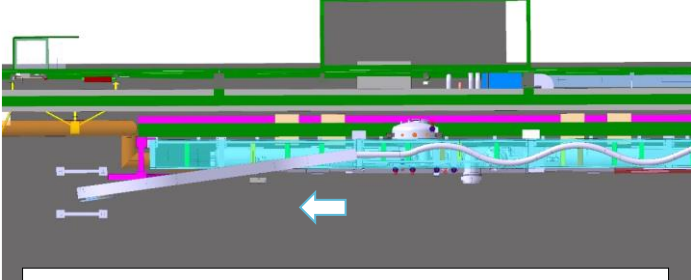
Installation of cable chain support



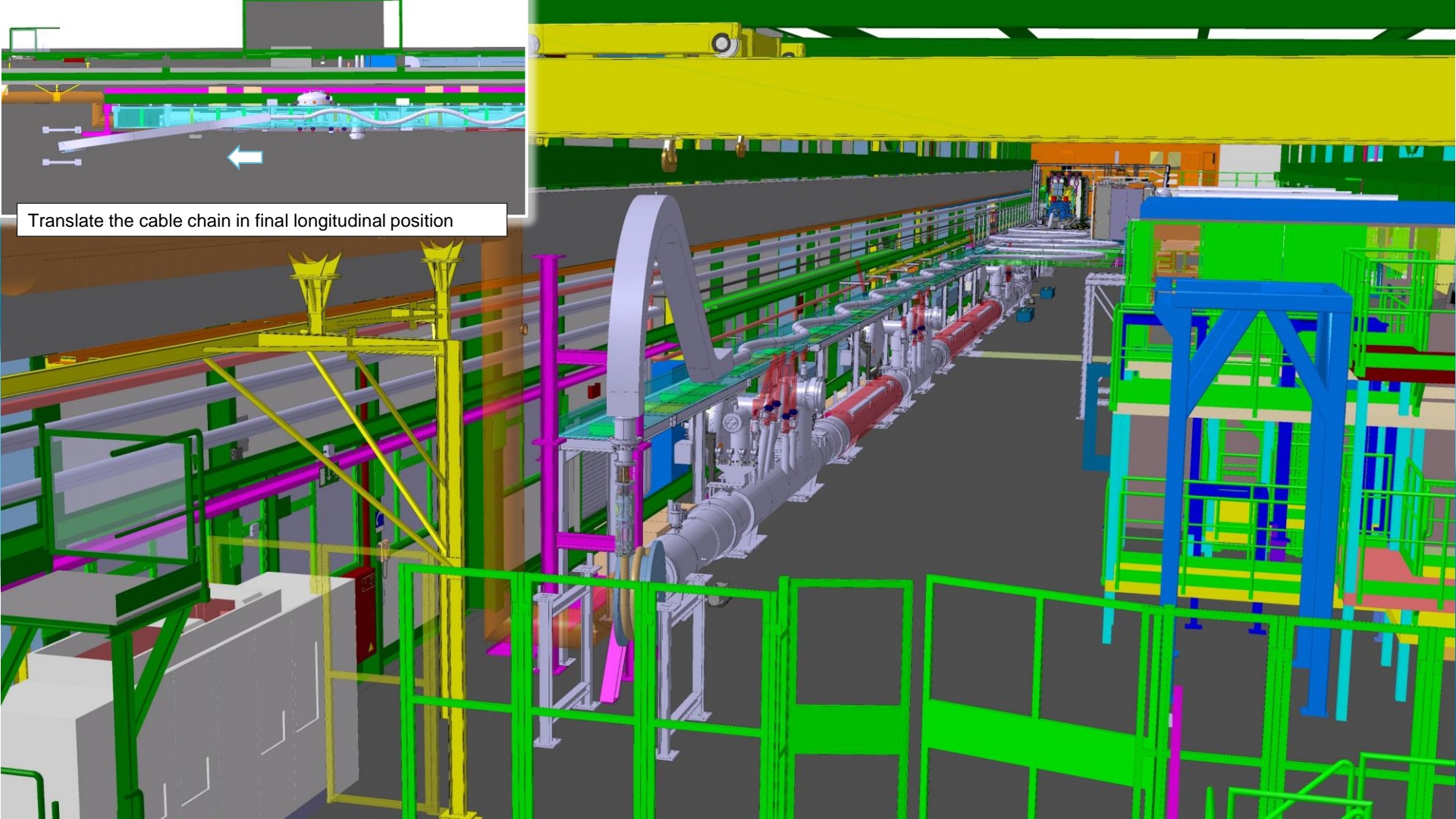


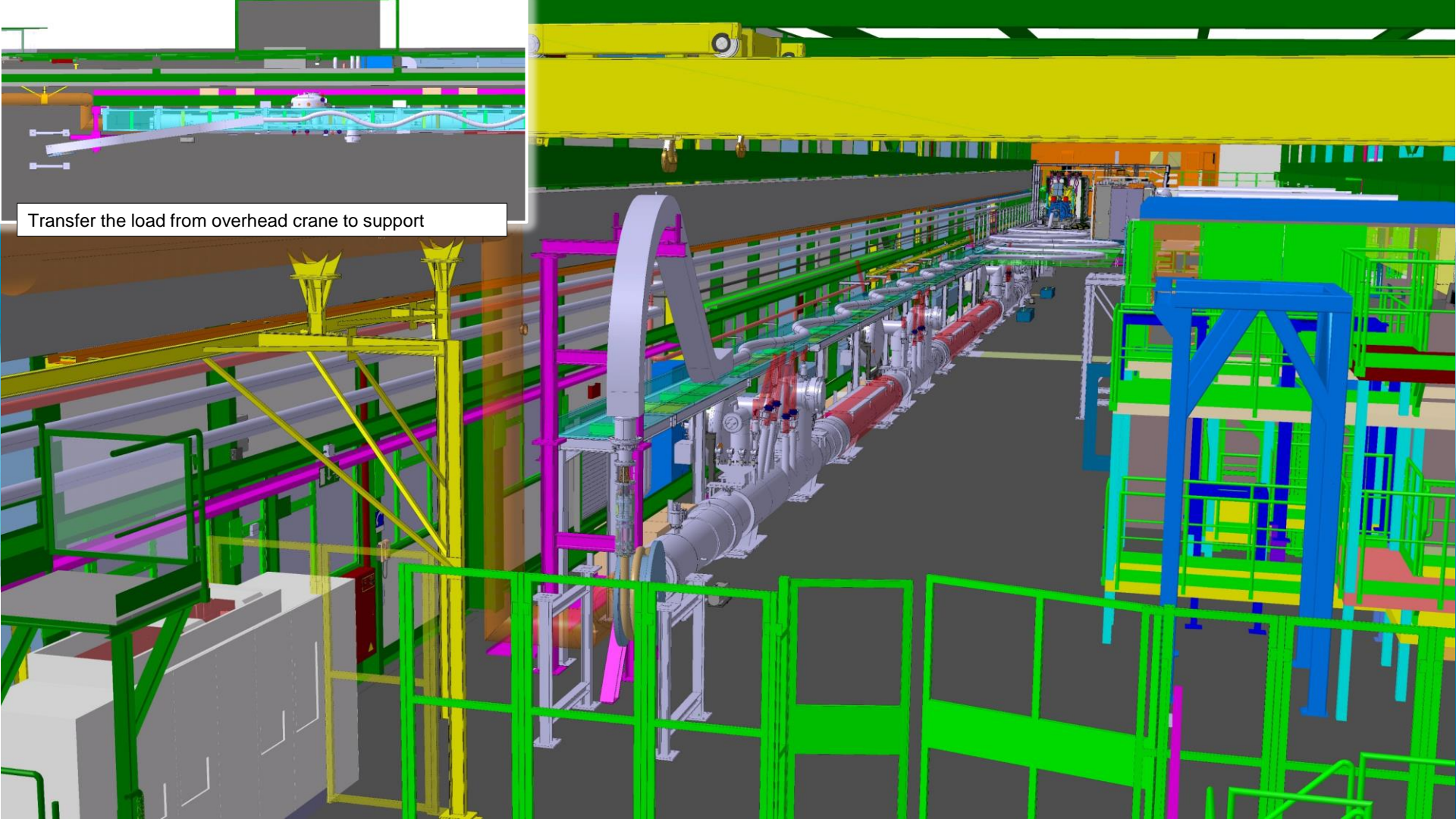
Apply curved shape (in-plane) to the cable chain with the **overhead crane***

**Experience with Proto taught to decouple the lifting and assembly operation and brought confidence and practice to operate with the overhead crane*

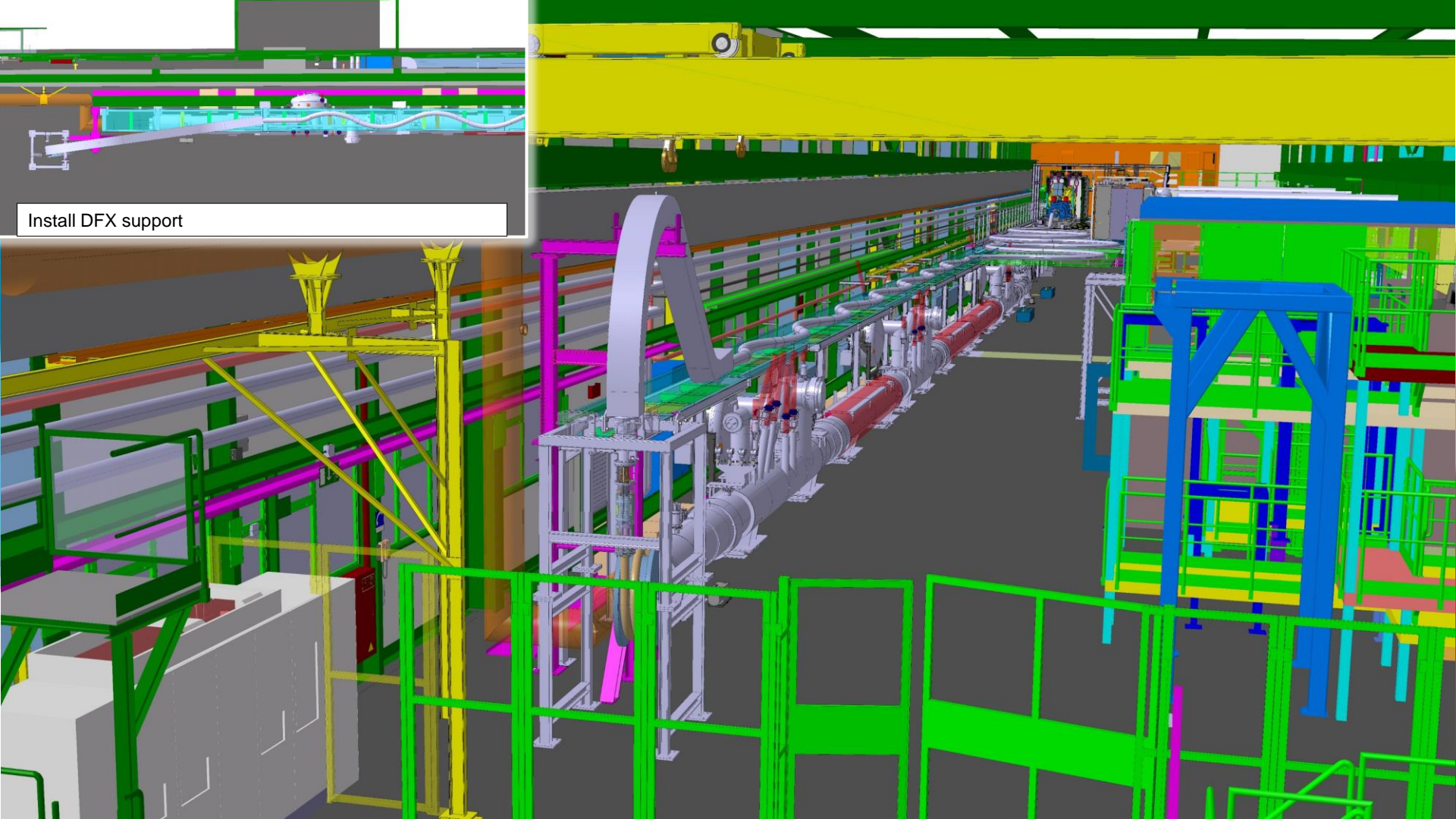


Translate the cable chain in final longitudinal position

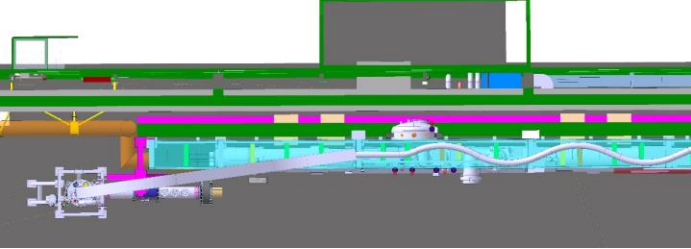




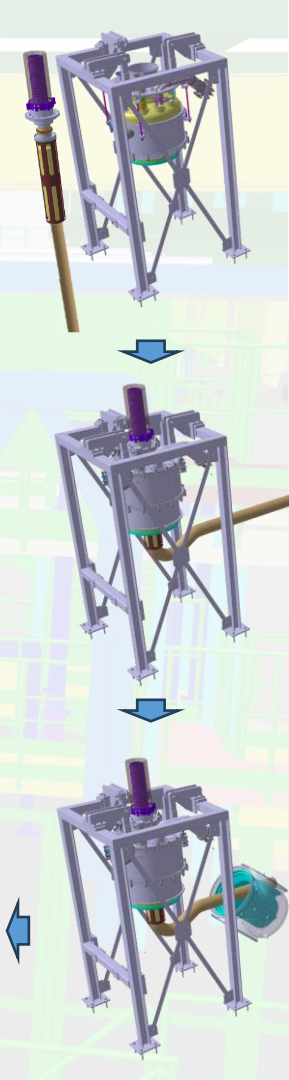
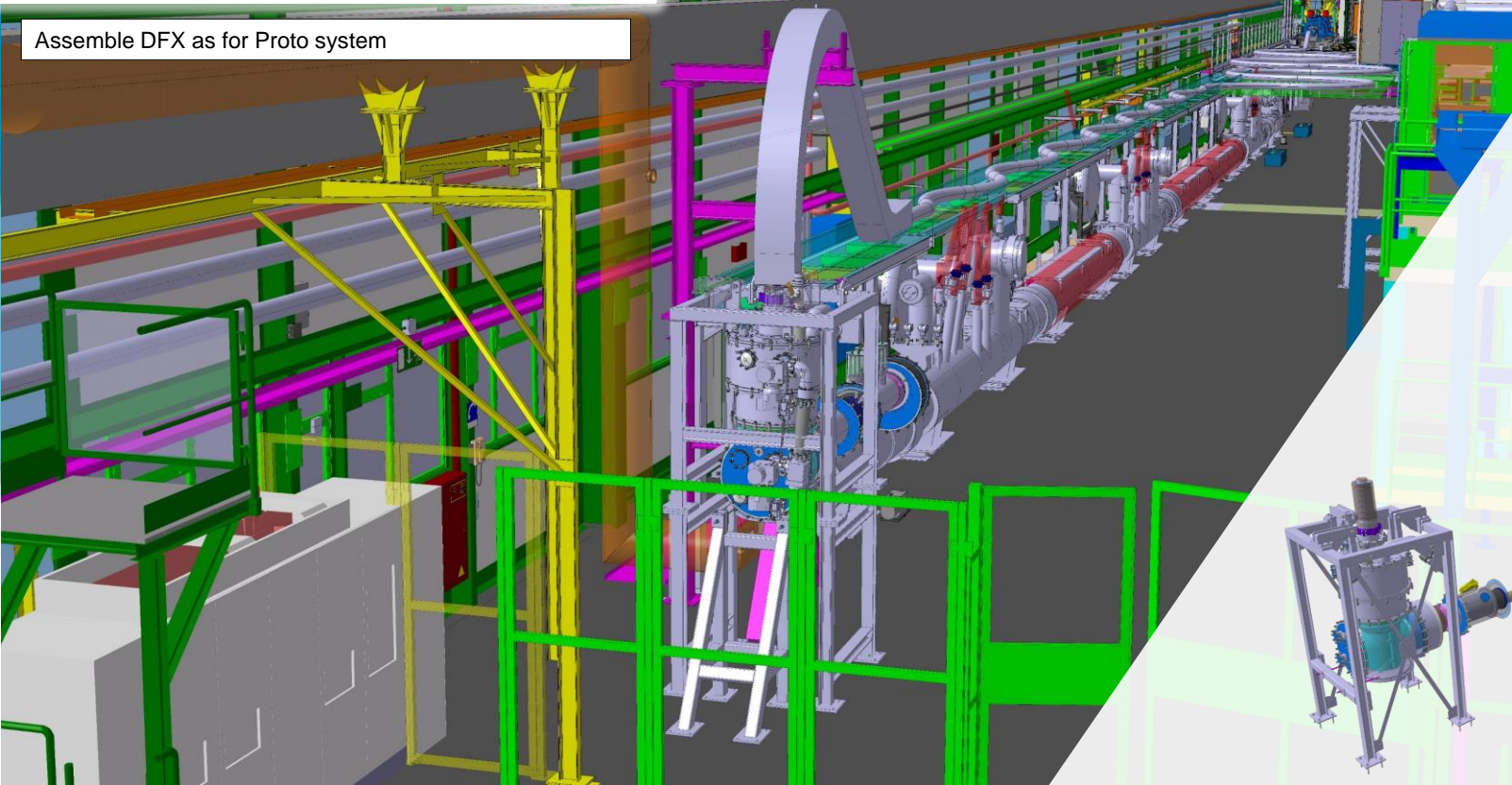
Transfer the load from overhead crane to support



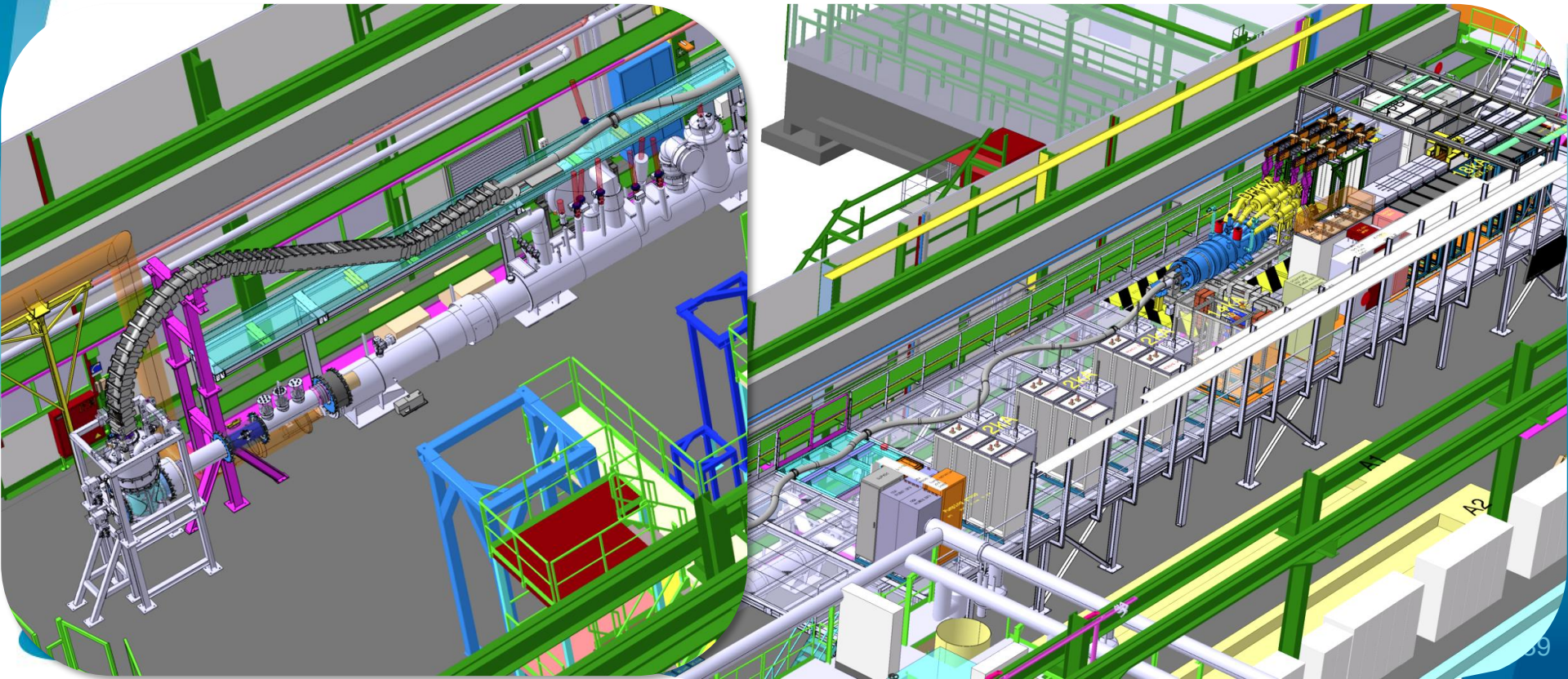
Install DFX support



Assemble DFX as for Proto system



Final configuration after WP6a assembly



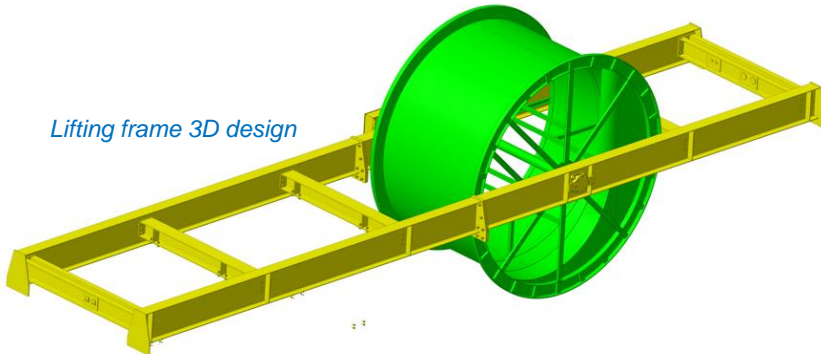
Tooling status

- Lifting & unspooling frame
 - Reception tests performed in UK in Aug. 23
 - Finishing in progress (motor break, painting), delivery by mid-October
- 4m spool
 - Practice with 60m long cryostat done
 - Spool optimization in progress
 - Availability by December 2023
- Practice plan with dummy SCLink
 - Unspooling in parallel building at reception
 - Unspooling on STRING plate-form (details to be defined)

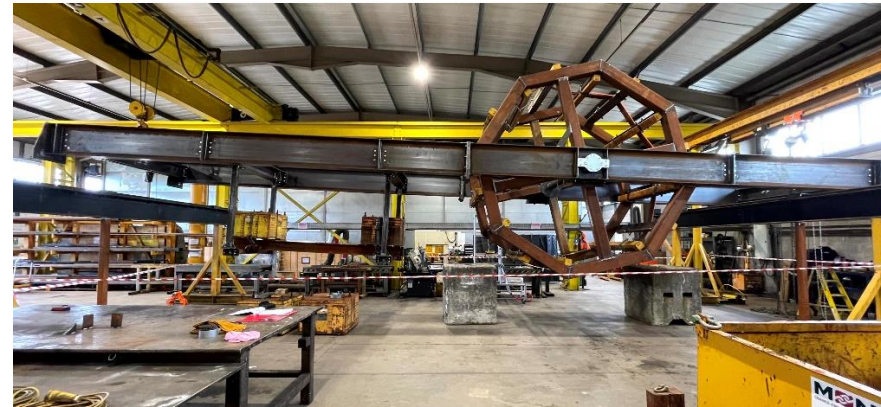
4m diameter Spool



Lifting frame 3D design

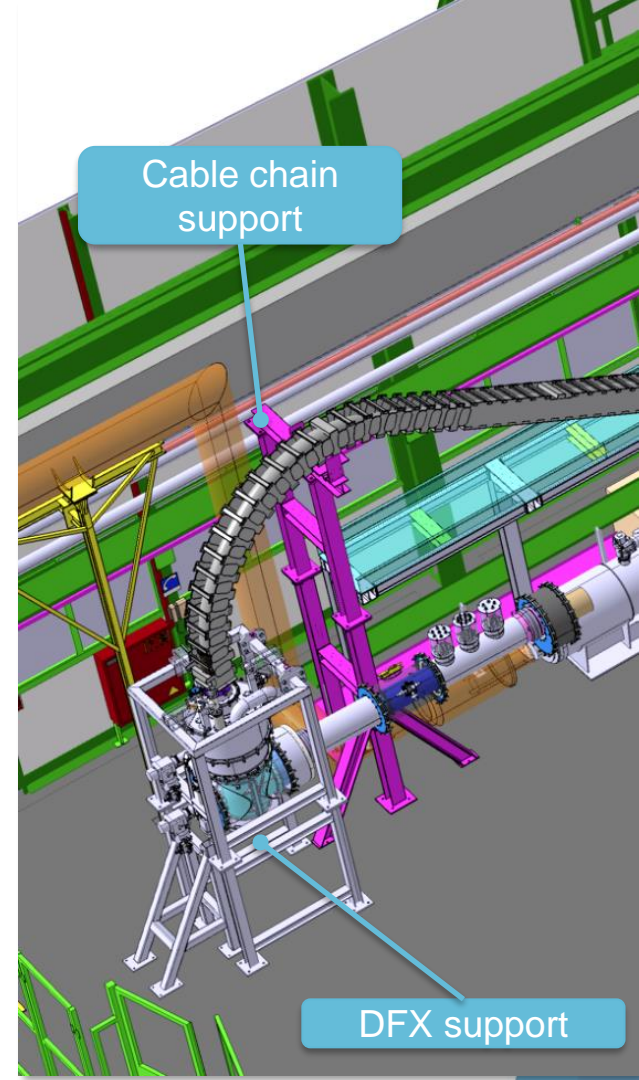


Lifting frame reception test



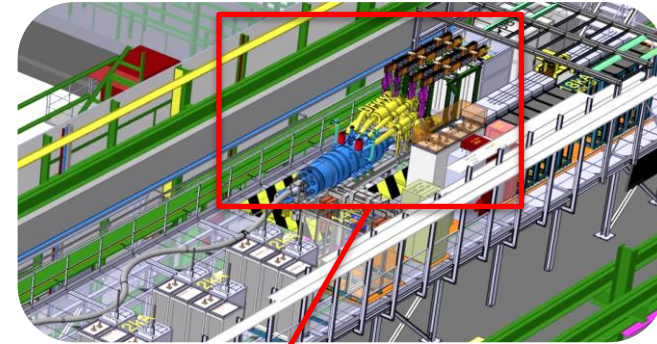
Tooling status

- Temporary **supports** of cable chain & SCLink to be finalized
- Cable chain support to be updated with **lessons learnt**
- DFX supporting structure : to be updated with **lessons learnt**
- **Objective** : received all tooling by end December

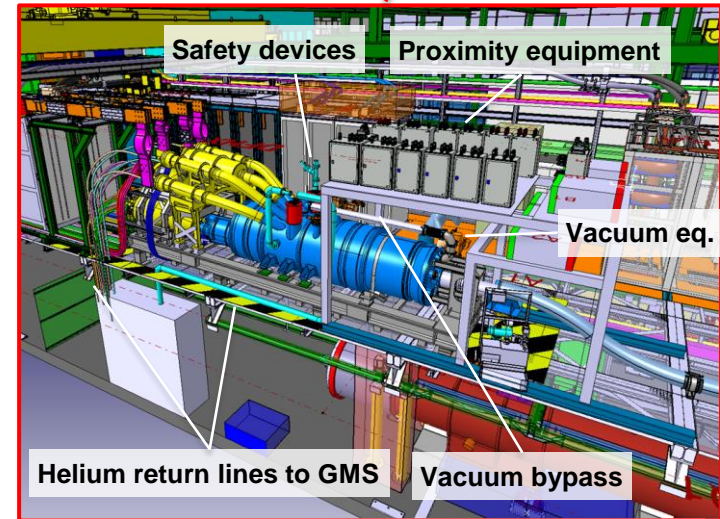


Integration of services & interfaces

- Vacuum equipment **layout**
 - Bypass line, pumping system, gauges, safety relief devices...
 - Position and access defined
- DFHX **proximity** equipment
 - Compromise between environment, services, access, safety devices...
 - Boxes being assembled within WP6a (ready by end 2023)
- Cryogenic **routing** lines to Gas Management system
 - Bypass return line design agreed with WP9
 - Final integration being studied
 - Warm return line from CL being routed
- Cryogenic line to DFX jumper
 - Design finalized, procurement starting soon



Illustrative integration study of the proximity equipment and cryogenic lines routing : study in progress



Readiness of WP6a for STRING installation

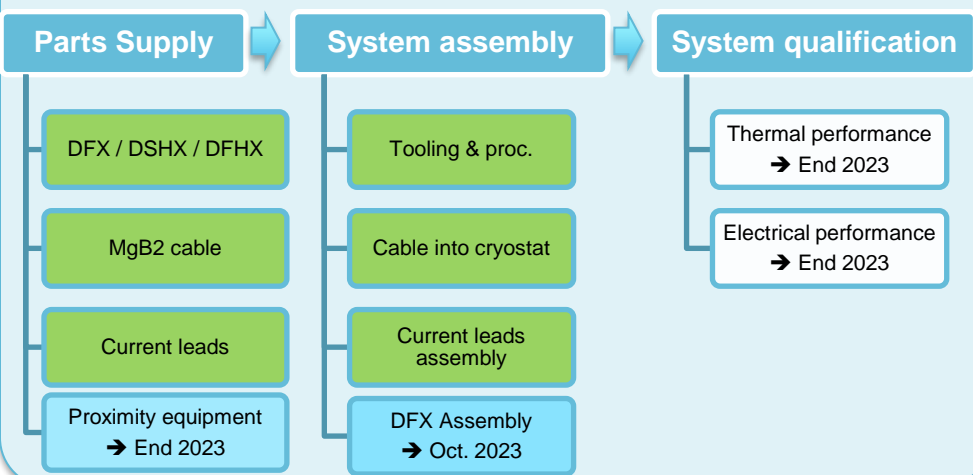
WP6a cold powering system

- Assembly completed : Oct. 2023
- Cold test : EOY 2023
- Availability for STRING : Jan. 2023
- Splices interconnect to WP3 : Q4-2023

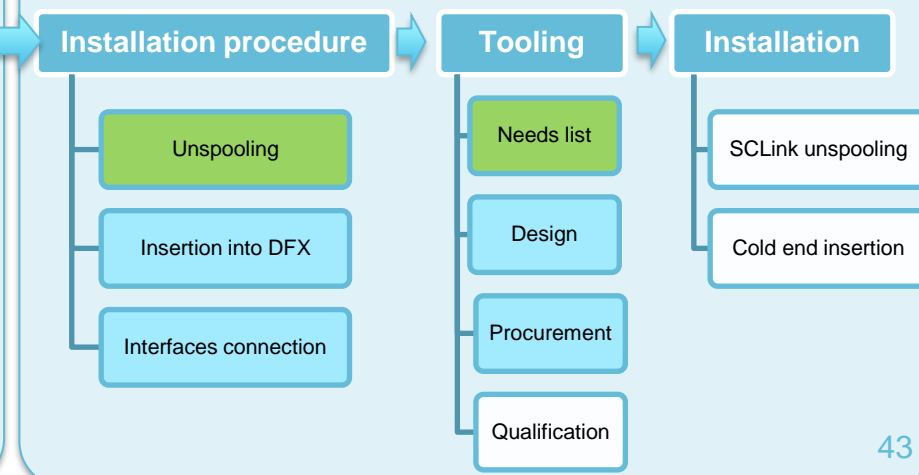
Infrastructure

- Tooling: Oct. 2023
- DFX Structures : EOY 2023
- Cryogenic interfaces : Jan. 2024

Cold Powering System Qualification process



Installation in STRING Preparation



Thank you for attention !



[New superconducting technologies for the HL-LHC and beyond – CERN Courier](https://home.cern/news/news/accelerators/electricity-transmission-reaches-even-higher-intensities)

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