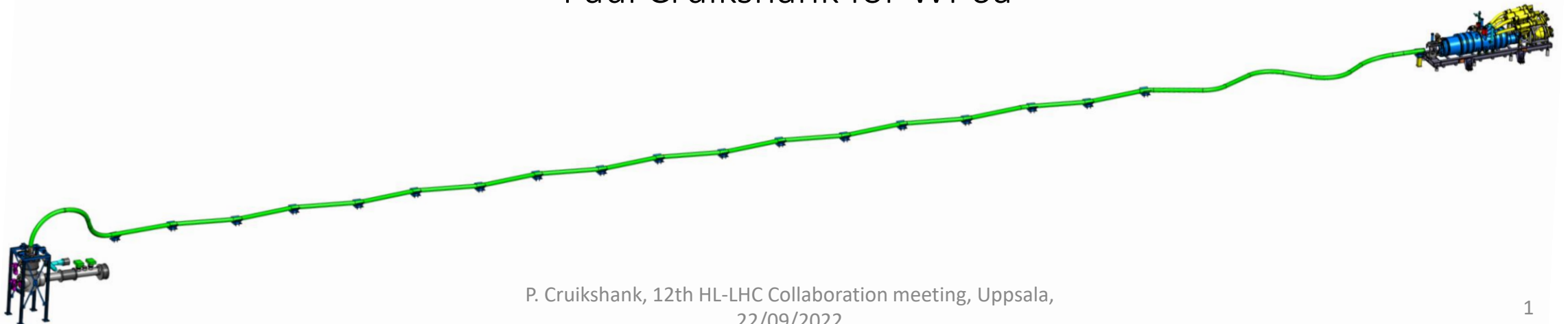


12<sup>th</sup> HL-LHC Collaboration Meeting,  
Uppsala, 19-22 Sept 2022

# Installation Strategy of the SC Link System in the IT String

22 Sept 2022

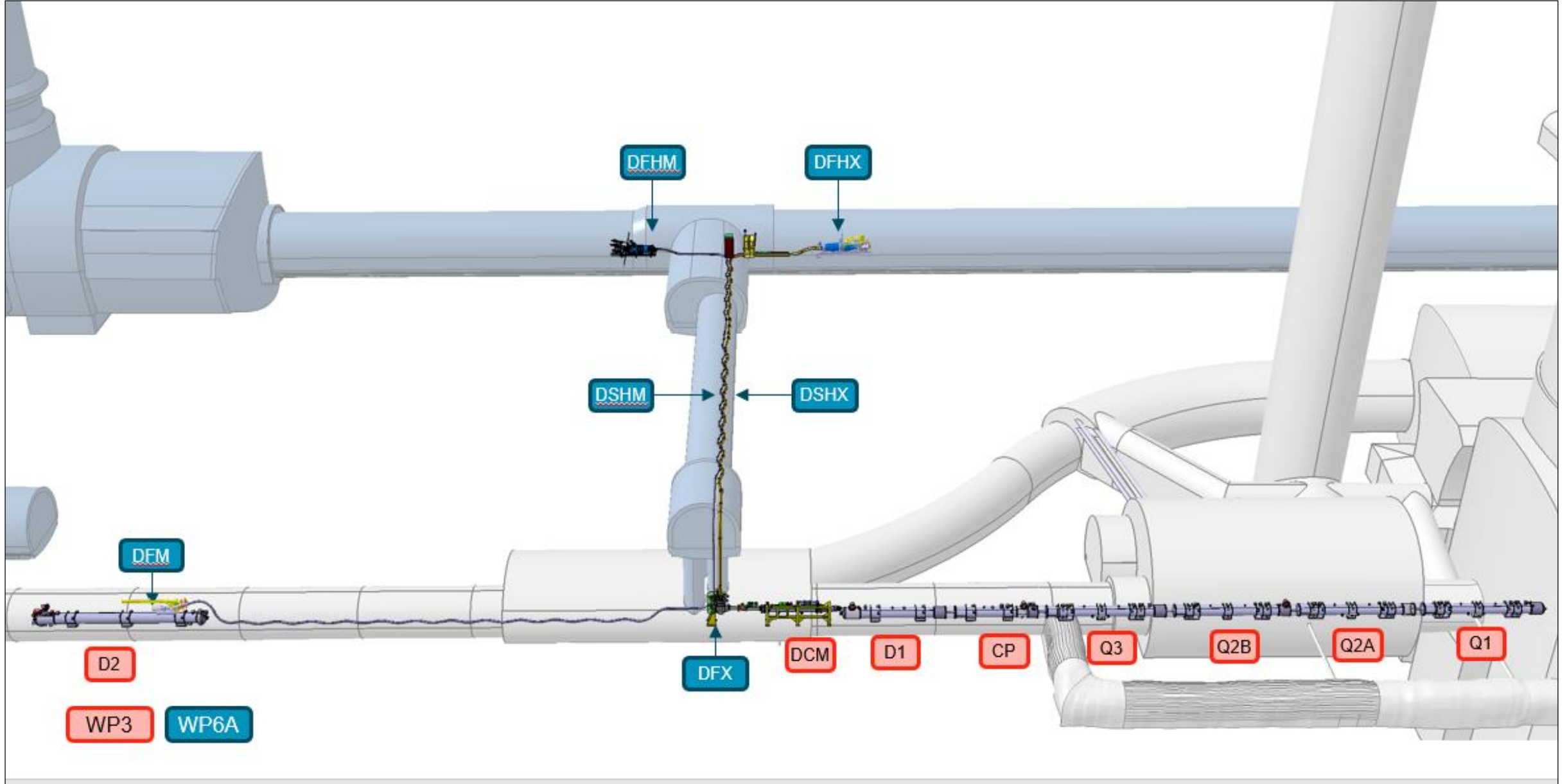
Paul Cruikshank for WP6a



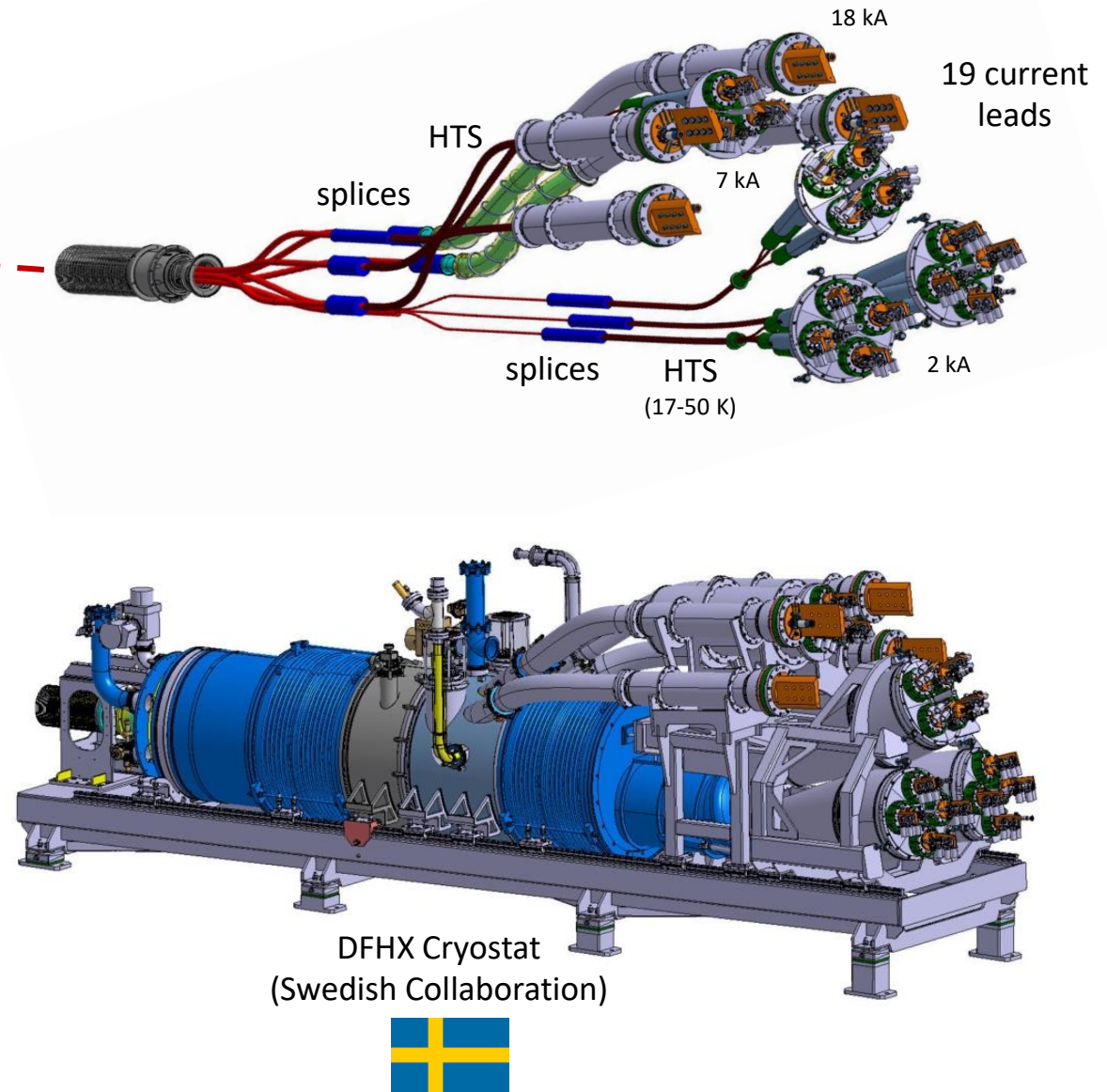
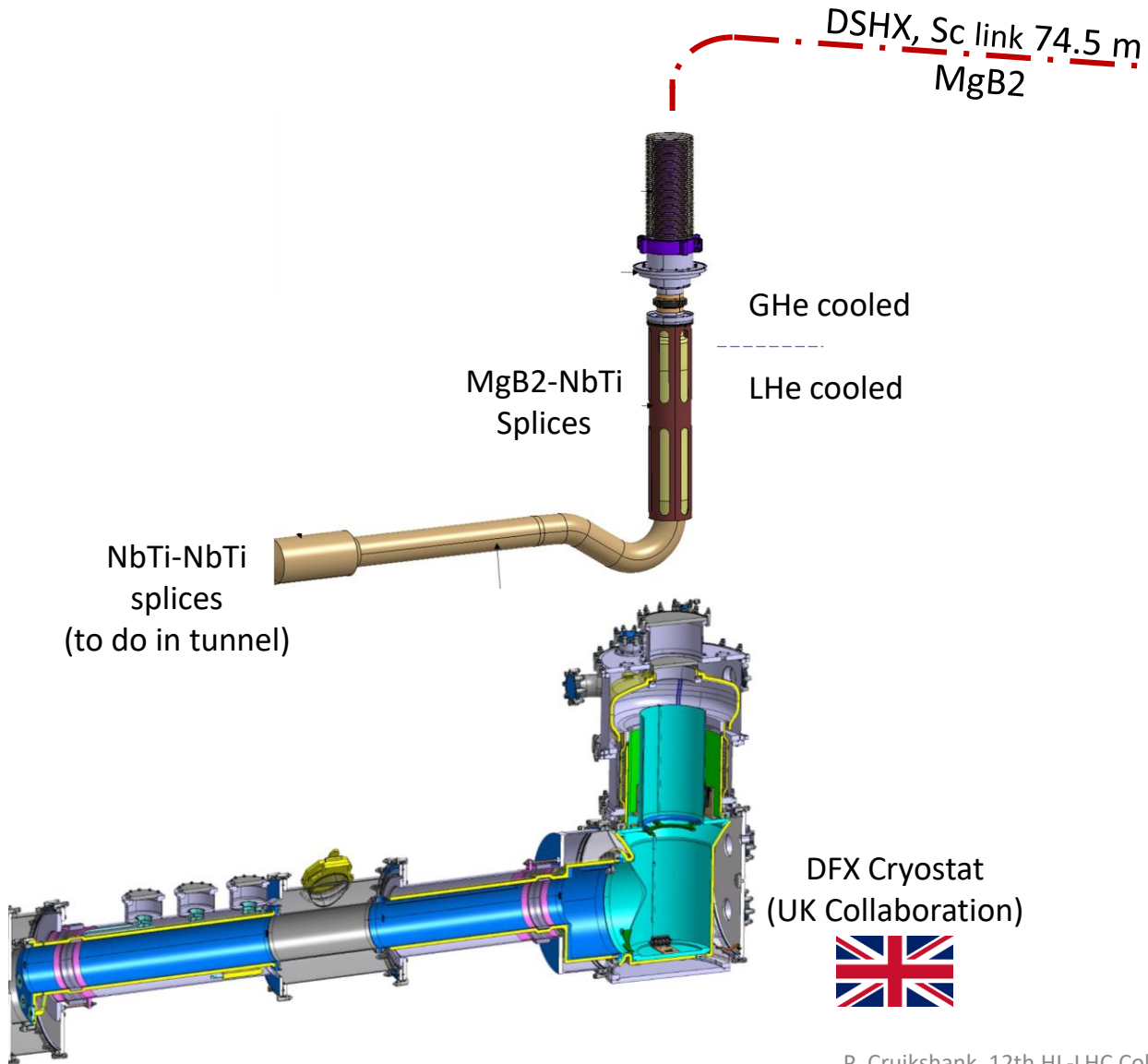
# Contents

- Cold Powering configurations: HL-LHC tunnel & IT String
- System qualification prior to IT String
- Installation at IT String
  - Equipment & tooling readiness
  - Installation sequence
  - Resources
- Summary

# Cold Powering for HL-LHC

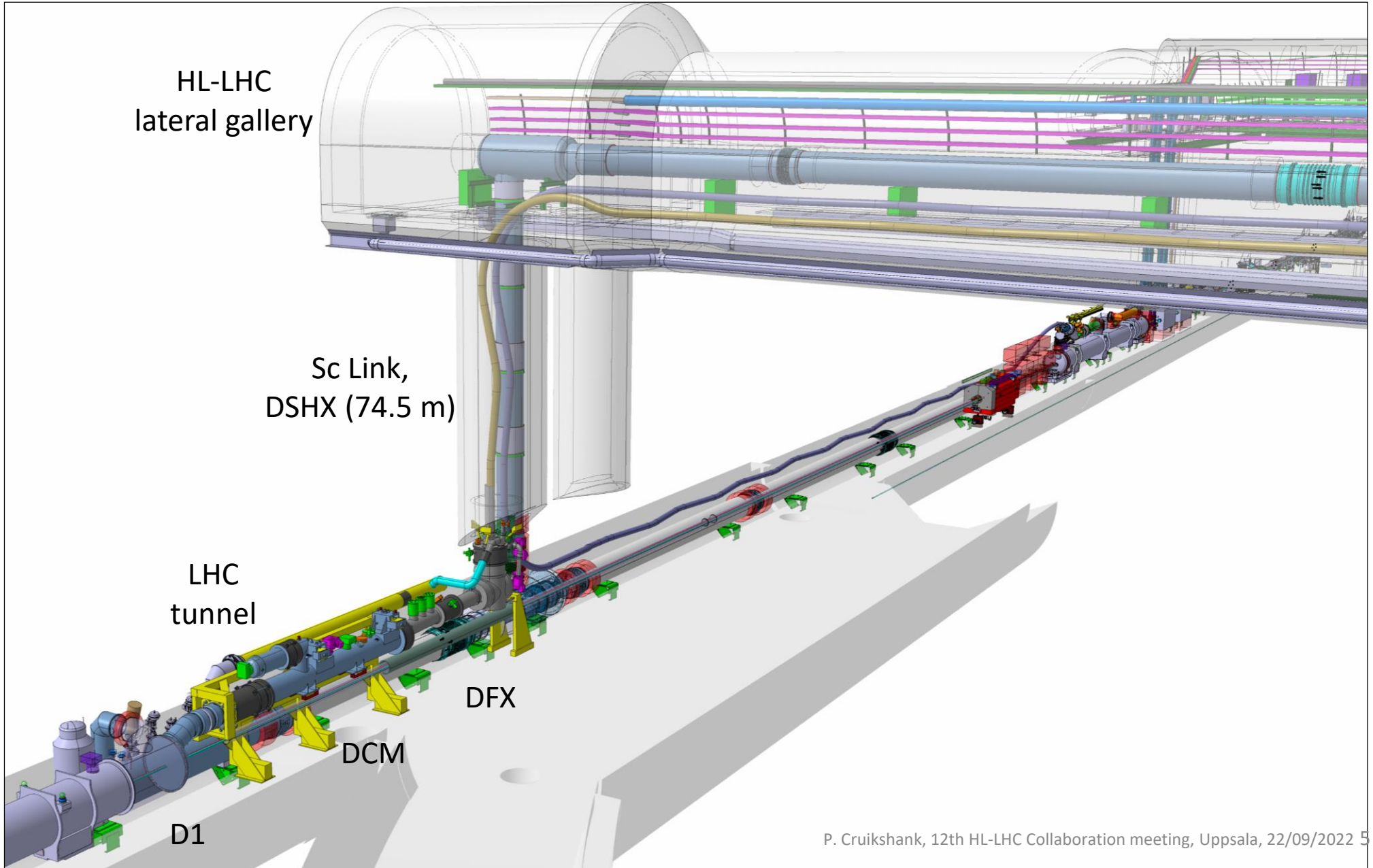


# Cold Powering for Triplets

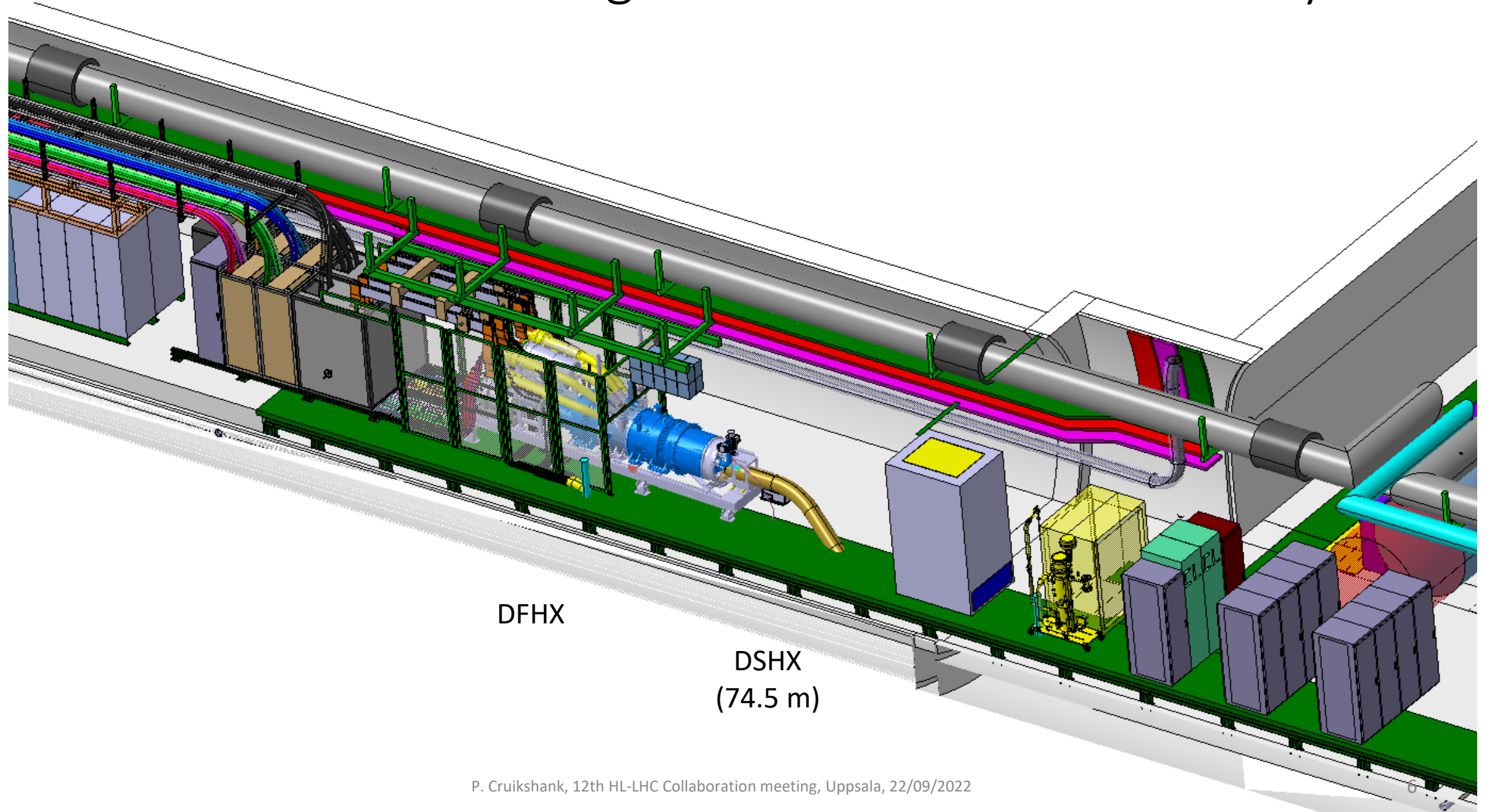




# Cold Powering for HL-LHC: DFX extremity



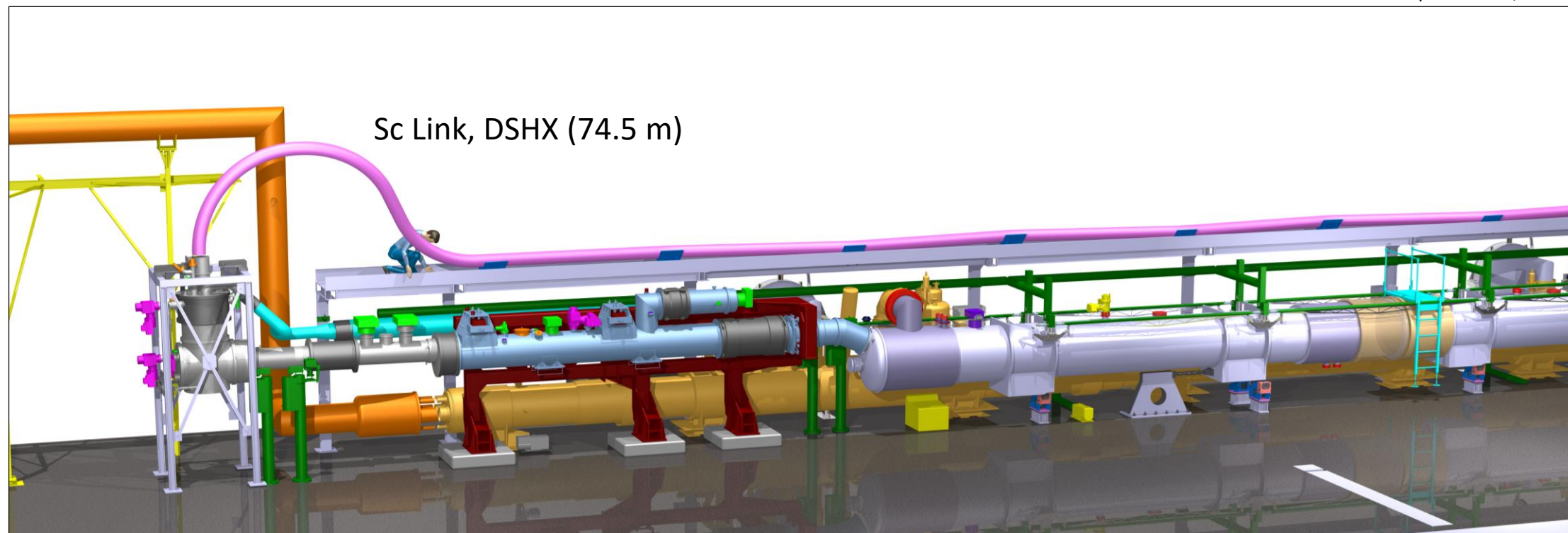
# Cold Powering for HL-LHC: DFHX extremity



# Cold Powering for IT String: DFX extremity

- Cold Powering is adapted to the SM18 environment, with Sc link length identical to the tunnel integration.
- Pre-series cold powering equipment will be used (machine spares).
- A controlled bend radius of the MgB<sub>2</sub> cable must always be respected.

Courtesy A.Kosmicki, WP16



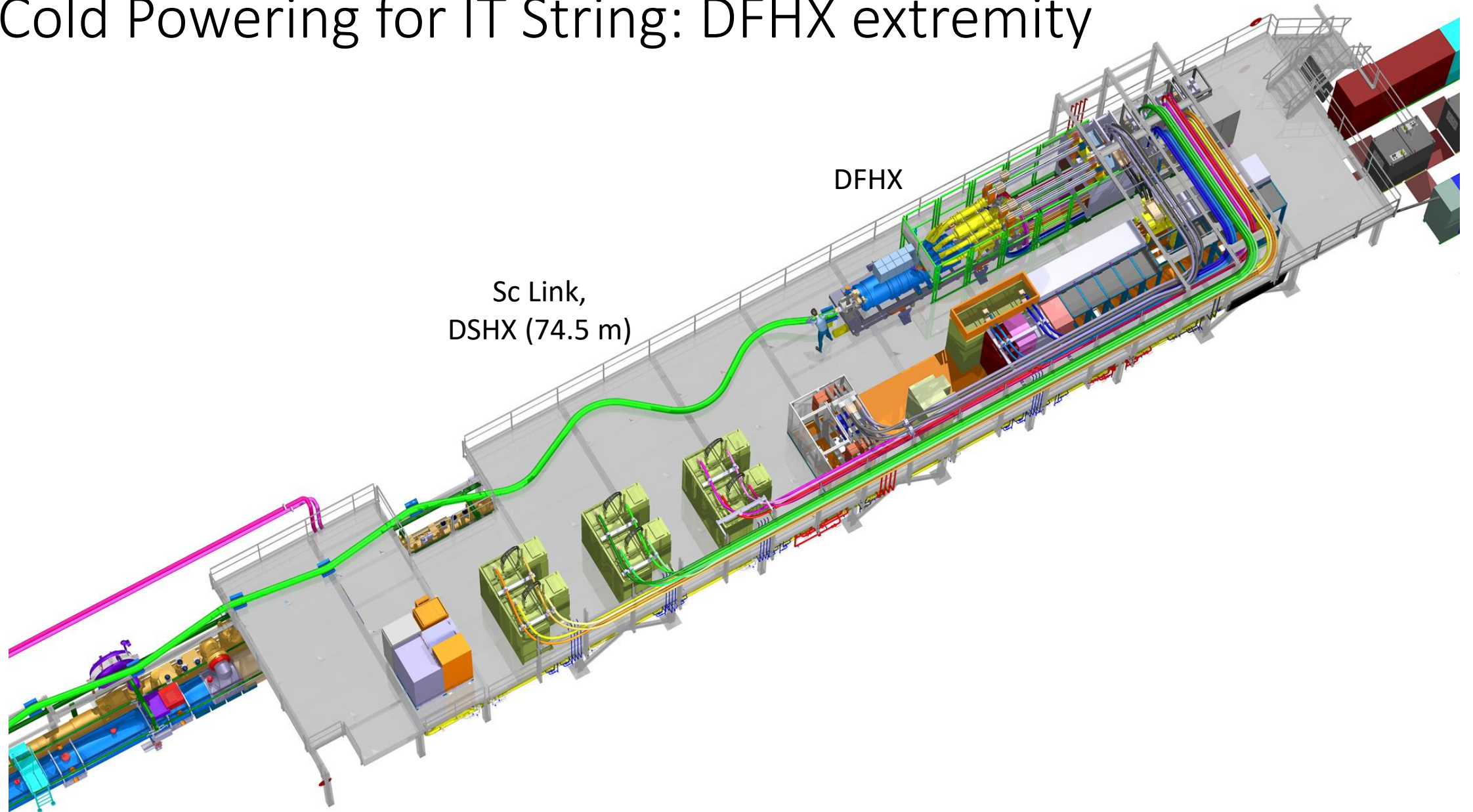
DFX

DCM

D1



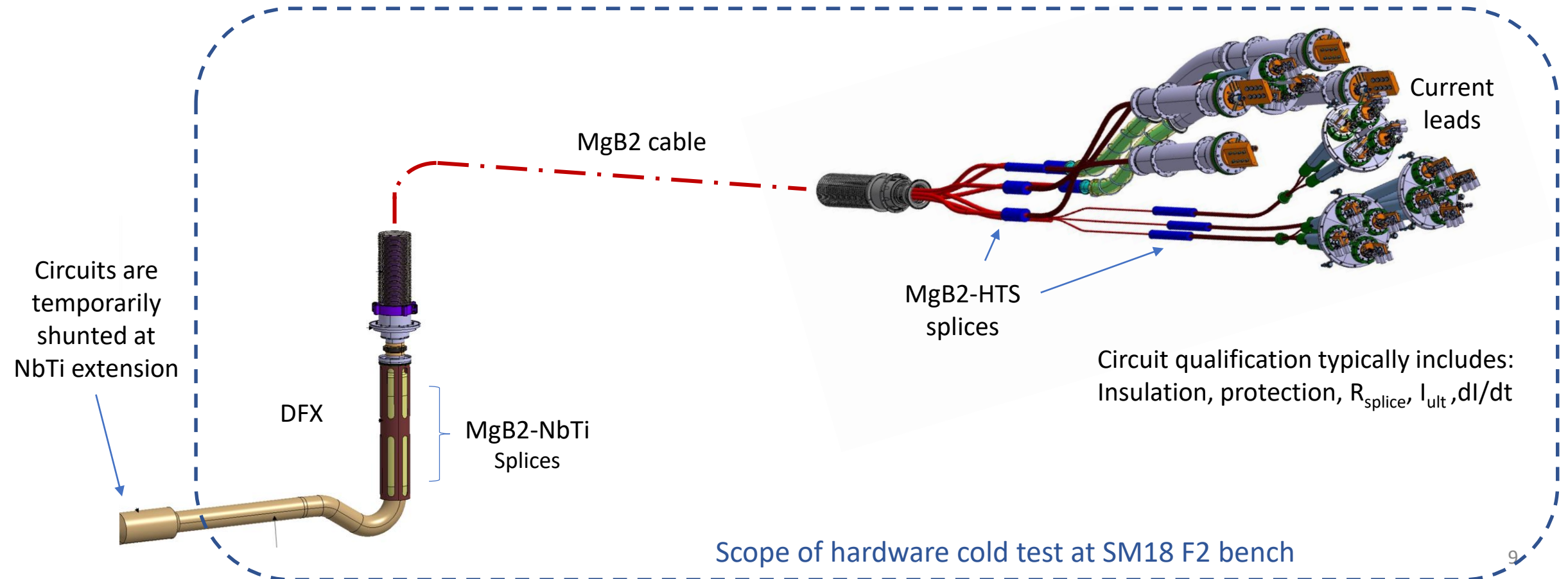
# Cold Powering for IT String: DFHX extremity



# System Qualification – before IT String (& LHC tunnel)

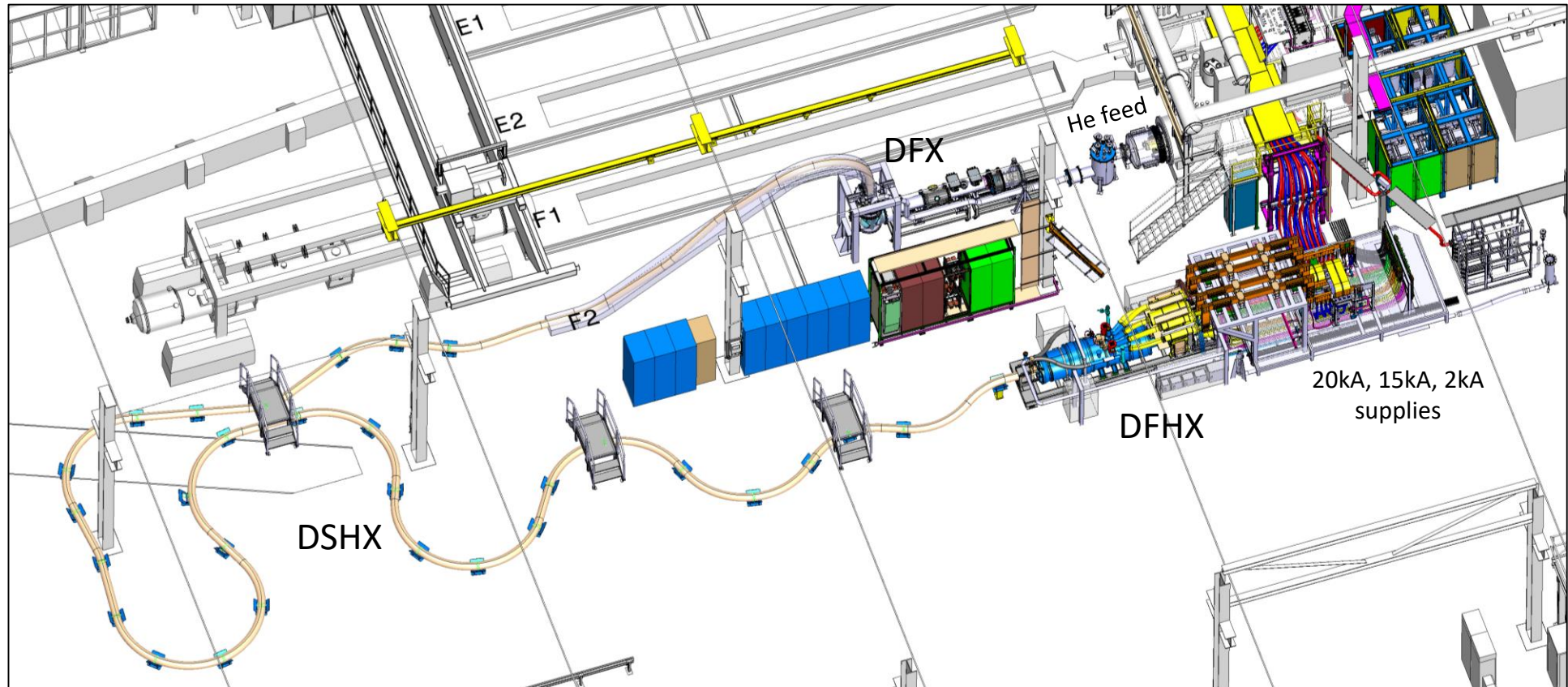
Before installing at IT String, we perform system qualification at cold in SM18:

- ⇒ Current leads (HTS REBCO),
- ⇒ MgB<sub>2</sub> cable,
- ⇒ MgB<sub>2</sub>-HTS splices, MgB<sub>2</sub>- NbTi splices
- ⇒ Embedded instrumentation (TT, Vtaps)
- ⇒ After cold test, removal of Sc link from DFX but, no disassembly of any MgB<sub>2</sub> splice



# F2 bench upgrade for Cold Powering System qualification

10 systems to test: 4 Triplet & 1 spare (for IT String) + 4 Matching Section(D2) & 1 spare



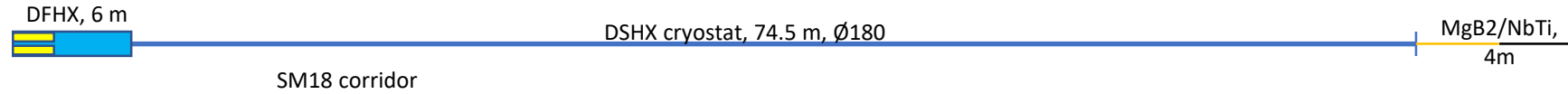
## Planning of 1<sup>st</sup> system test (SCR edms 2747986):

- Start system assembly – Oct 2022
- Ready for cooldown – March 2023
- Cold tests – April to June 2023
- Disassembly & delivery to String – July 2023

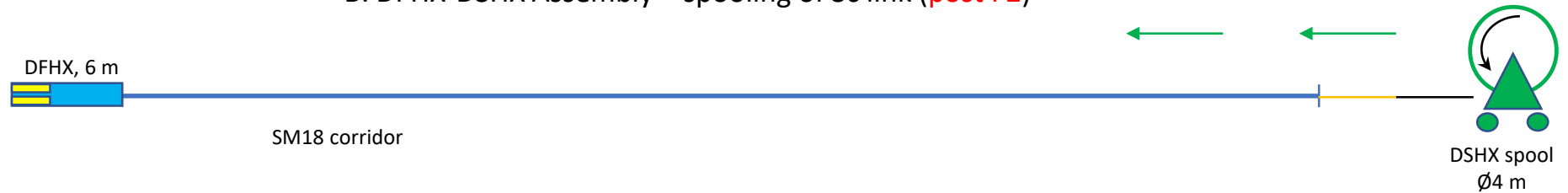


# DFHX/DSHX preparation for the IT String

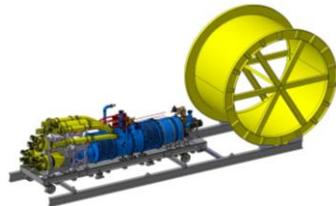
## A. DFHX-DSHX Assembly – electro-mechanical activities on Sc link extremities (pre F2)



## B. DFHX-DSHX Assembly – spooling of Sc link (post F2)



## C. DFHX-DSHX Assembly – spooling of Sc link (post F2, ready for IT String)

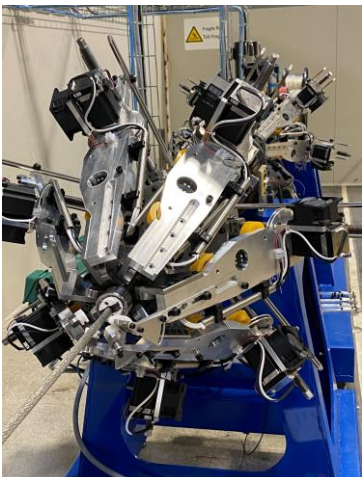


# Equipment Readiness

All principal components for IT String will first be deployed at F2 bench



Current leads



HTS cable



DSHX cryostat



DFX cryostat

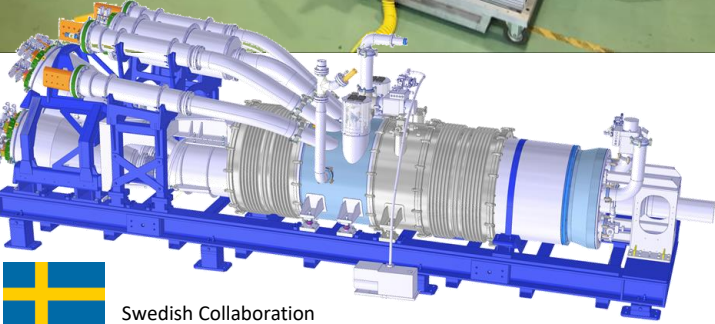


DFHX cryostat

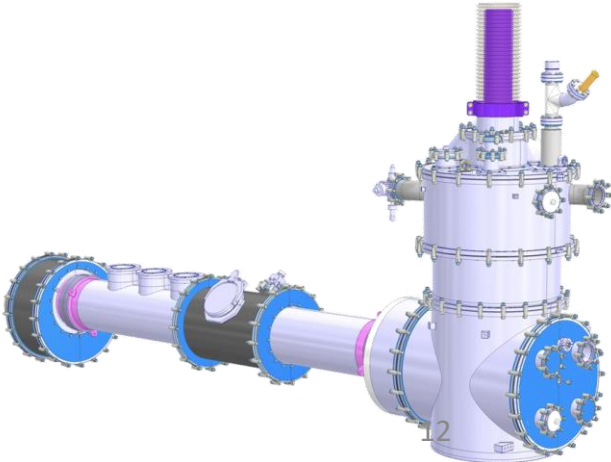
MgB<sub>2</sub> cables



UK Collaboration



Swedish Collaboration



# Cold powering assembly sequence at IT String

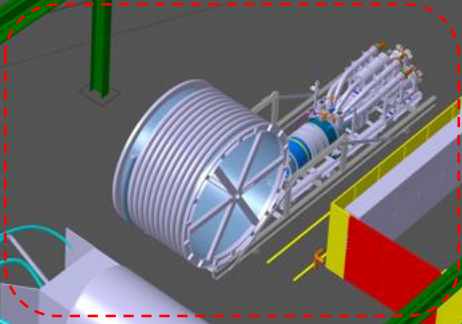
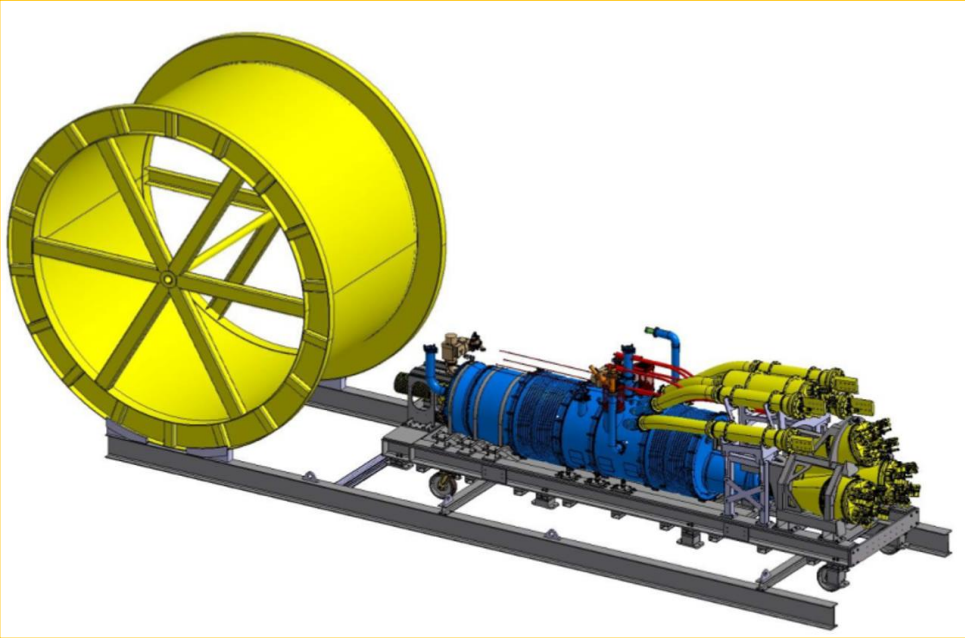
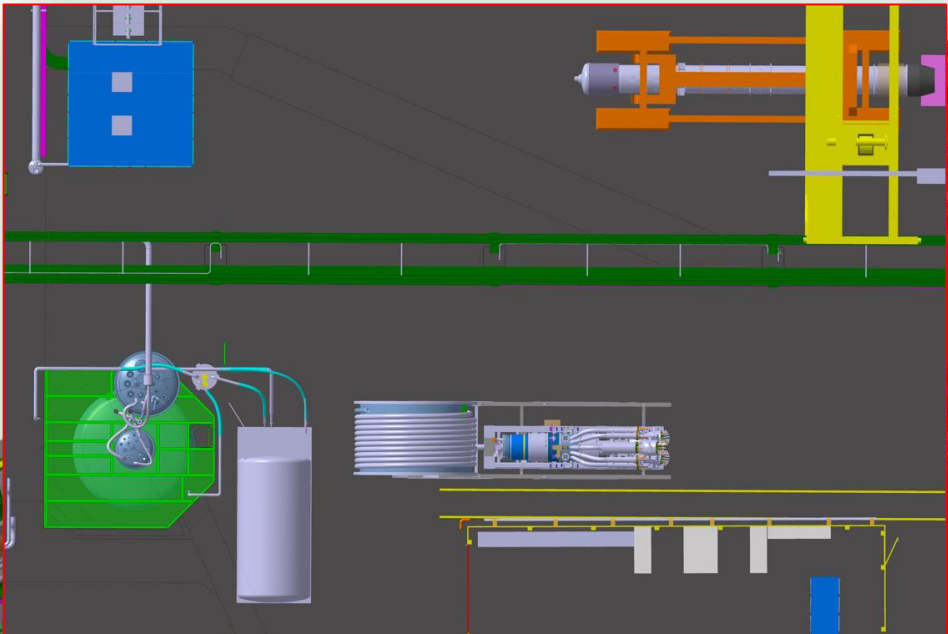
02/09/2022

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

- ⇒ Lifting of DFHX with 74.5 m Sc link on to platform
- ⇒ Insertion of Sc link into DFX



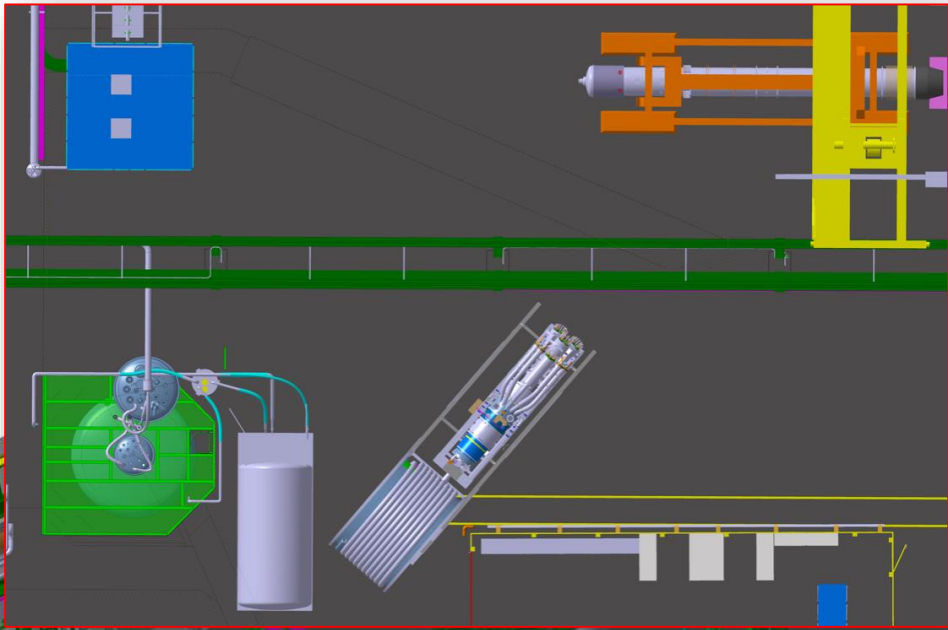
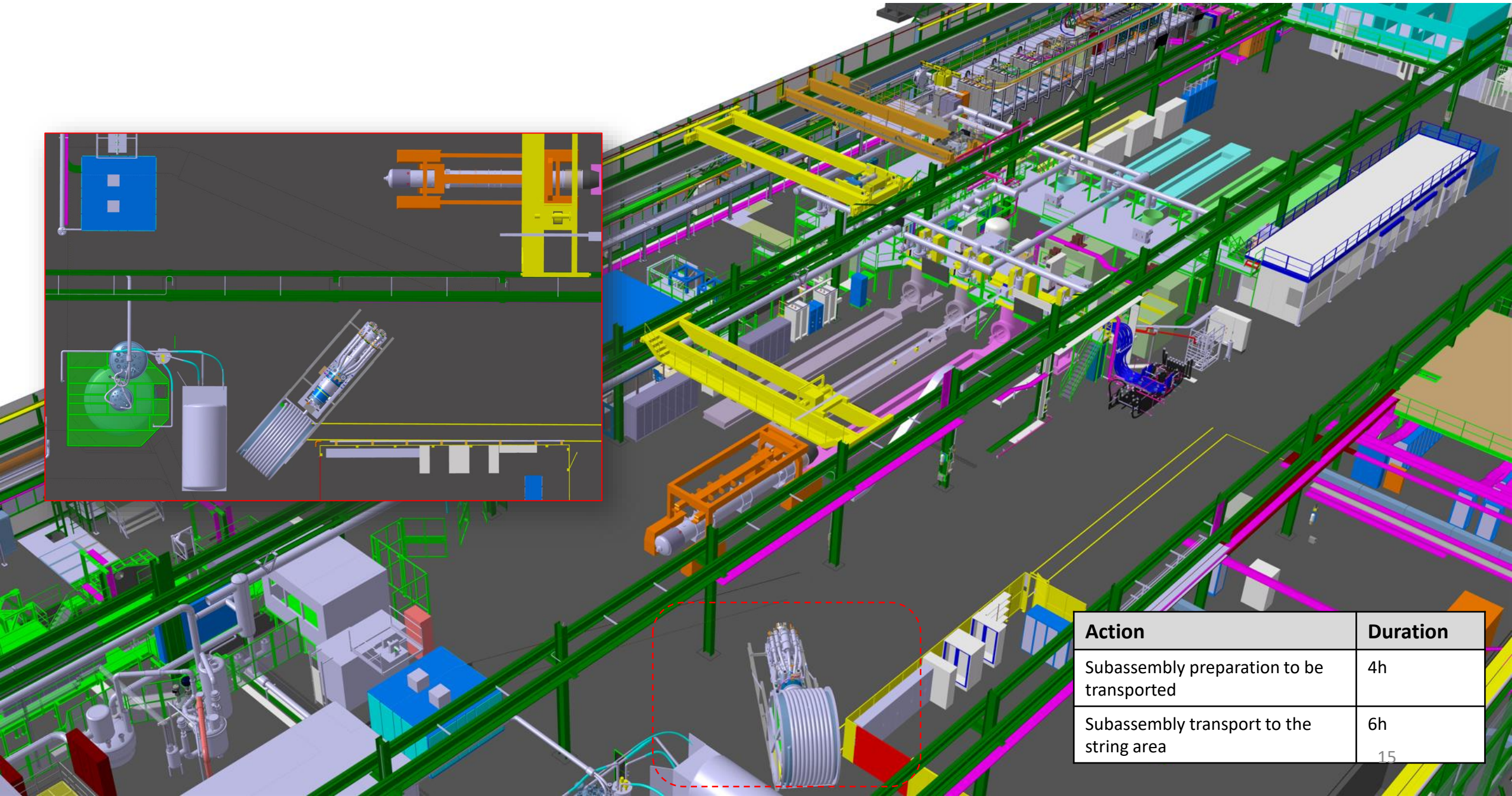
# Phase 0: DFHx-SCLink subassembly transportation



Action	Duration
Subassembly preparation to be transported	4h
Subassembly transport to the string area	6h



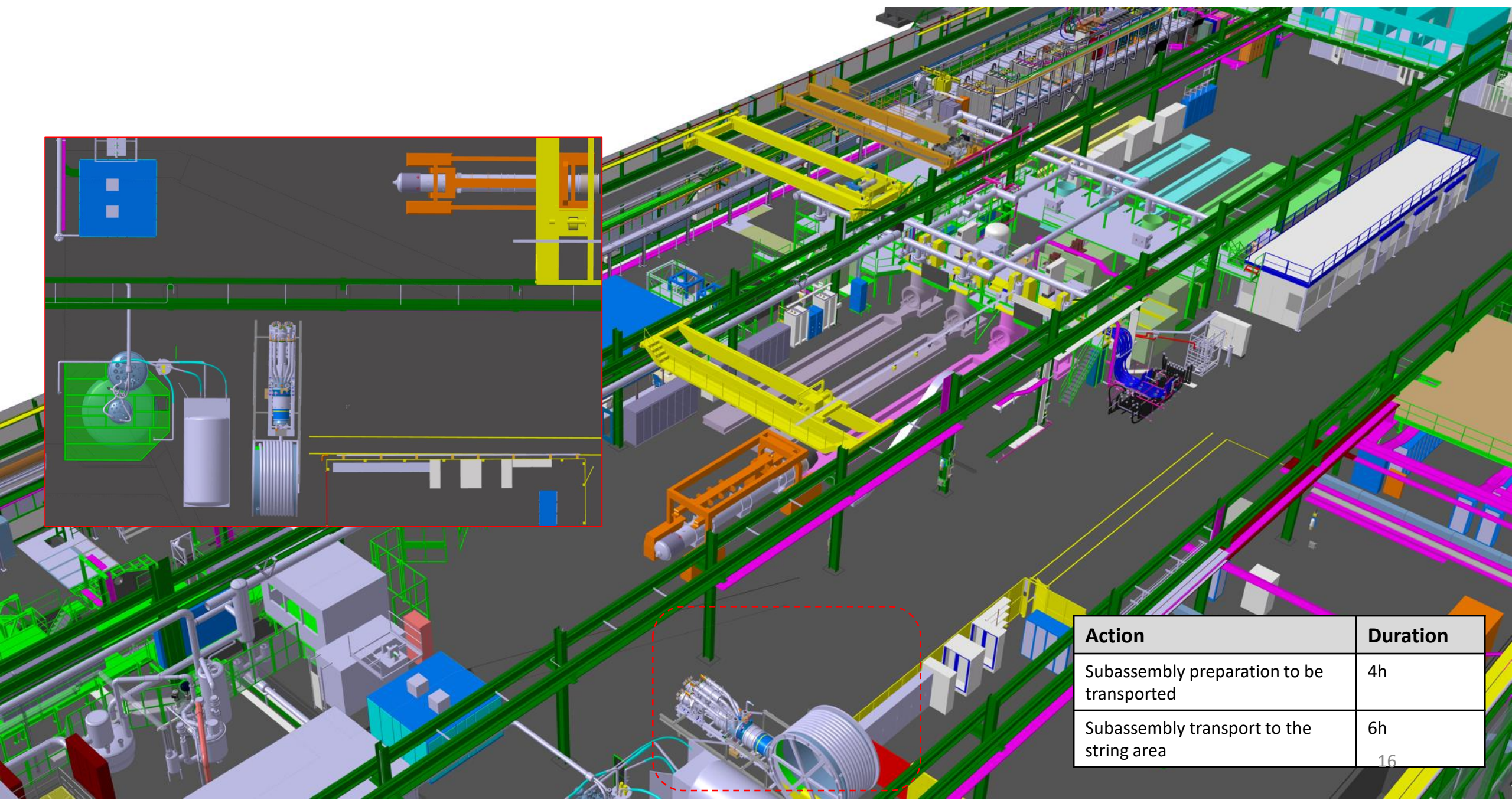
# Phase 0: DFHx-SCLink subassembly transportation



Action	Duration
Subassembly preparation to be transported	4h
Subassembly transport to the string area	6h



# Phase 0: DFHx-SCLink subassembly transportation

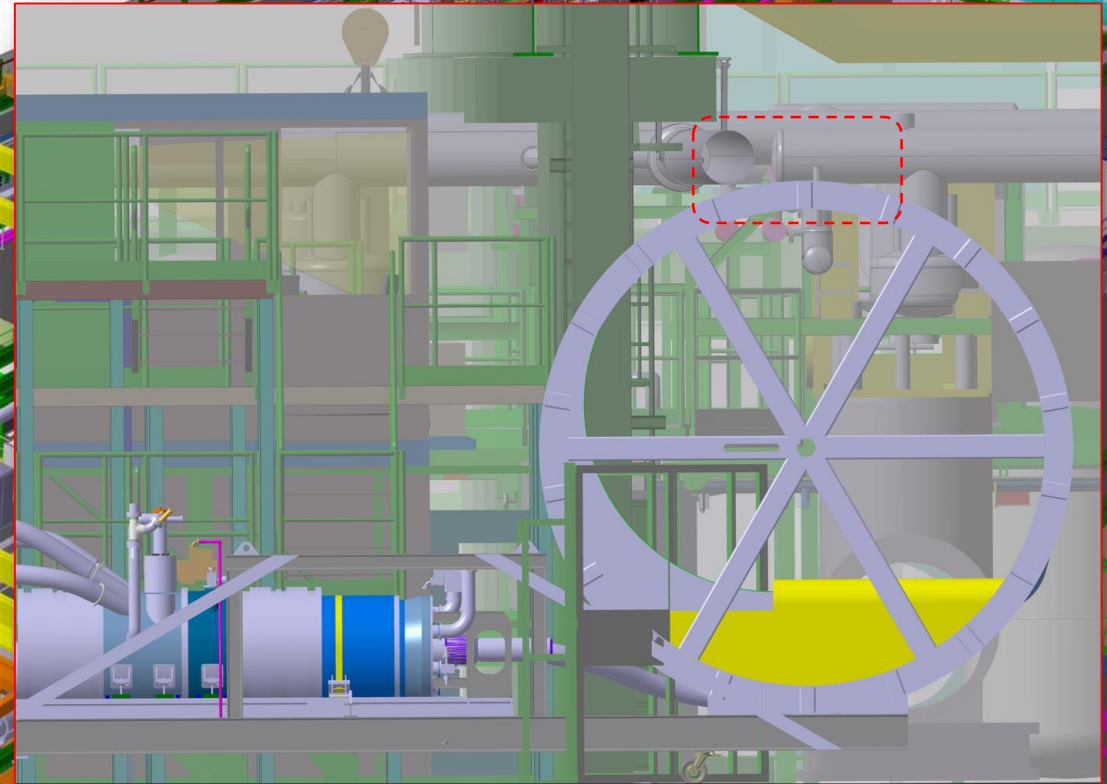
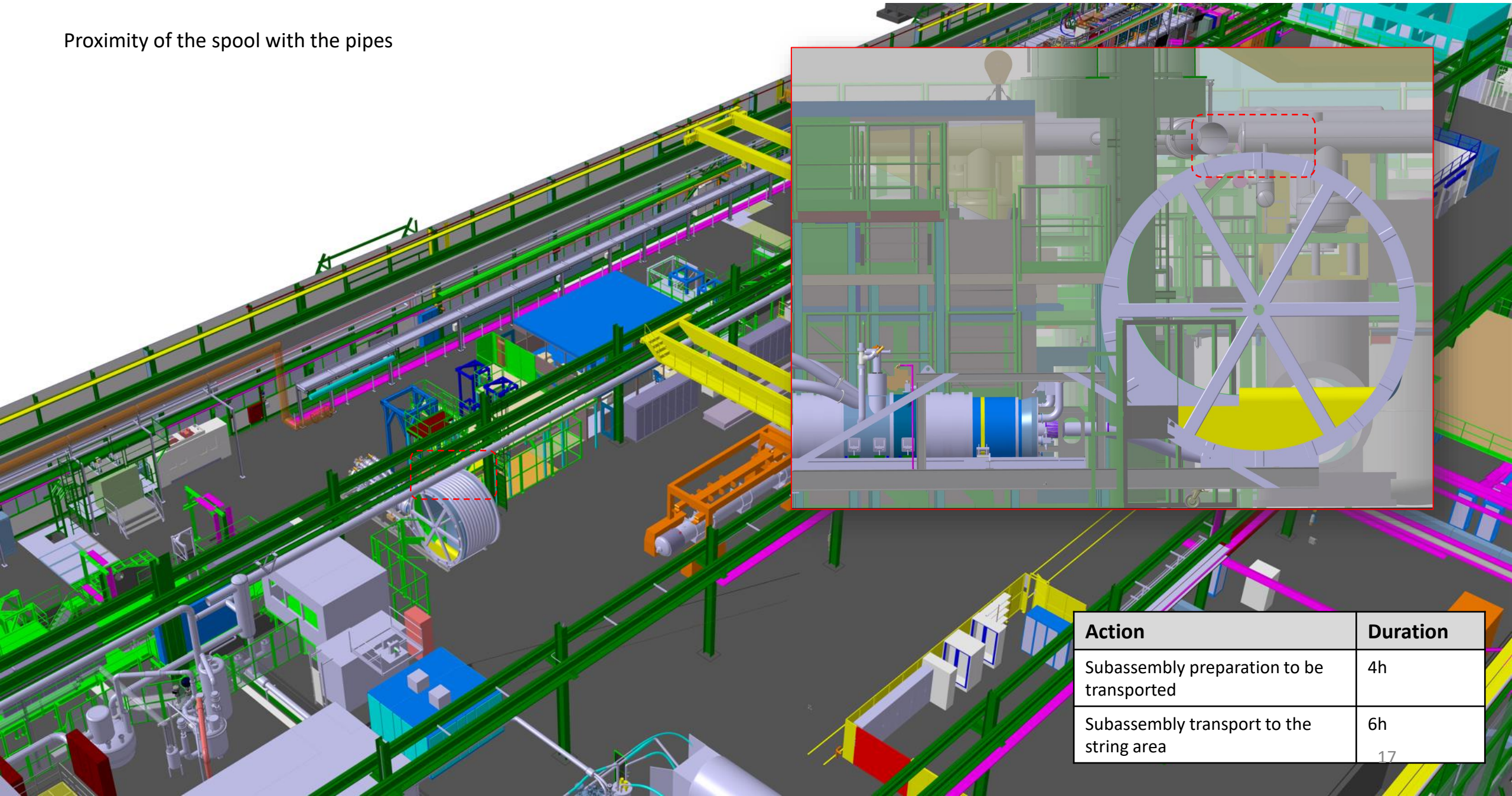


Action	Duration
Subassembly preparation to be transported	4h
Subassembly transport to the string area	6h



# Phase 0: DFHx-SCLink subassembly transportation

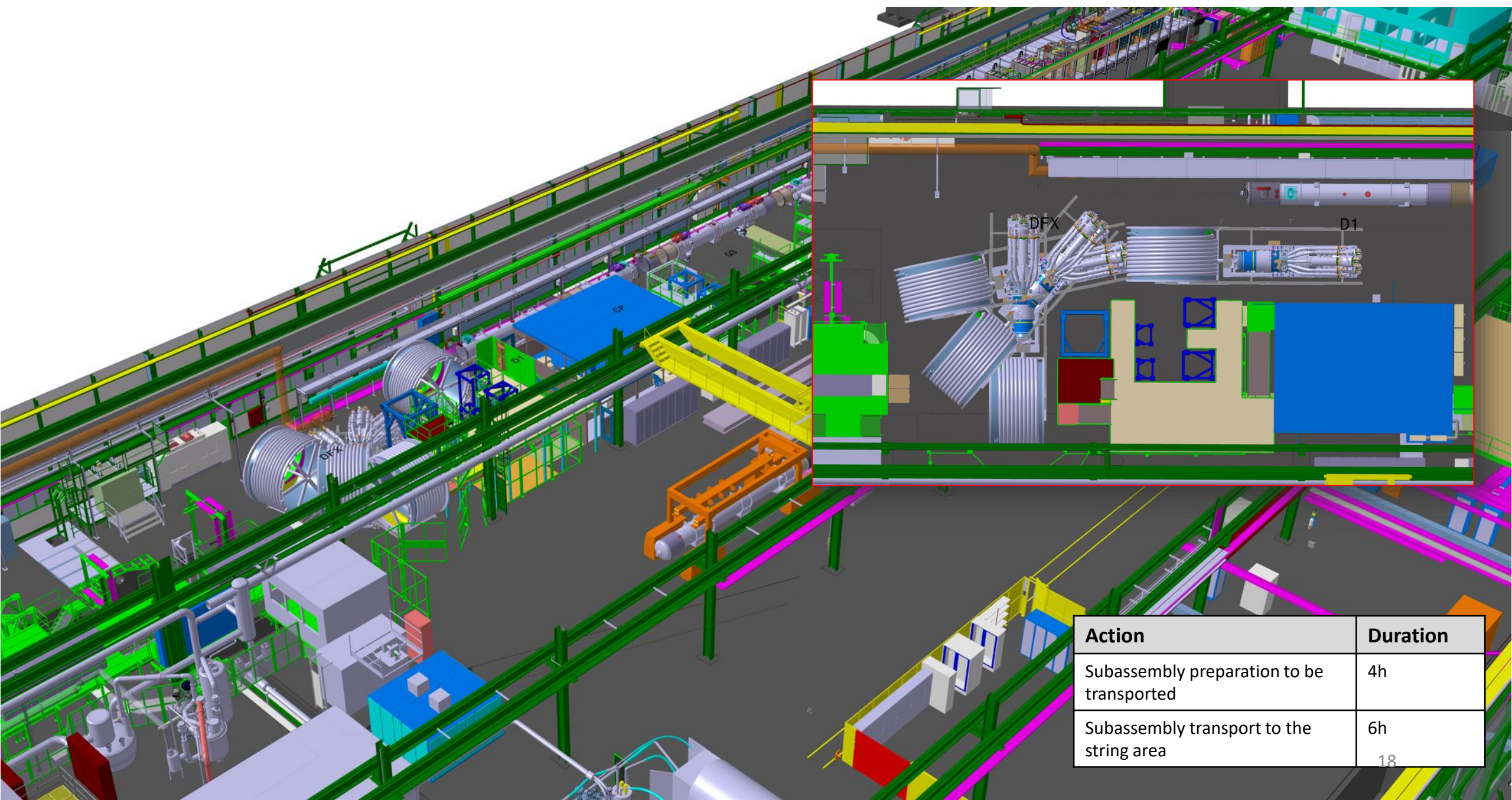
Proximity of the spool with the pipes



Action	Duration
Subassembly preparation to be transported	4h
Subassembly transport to the string area	6h



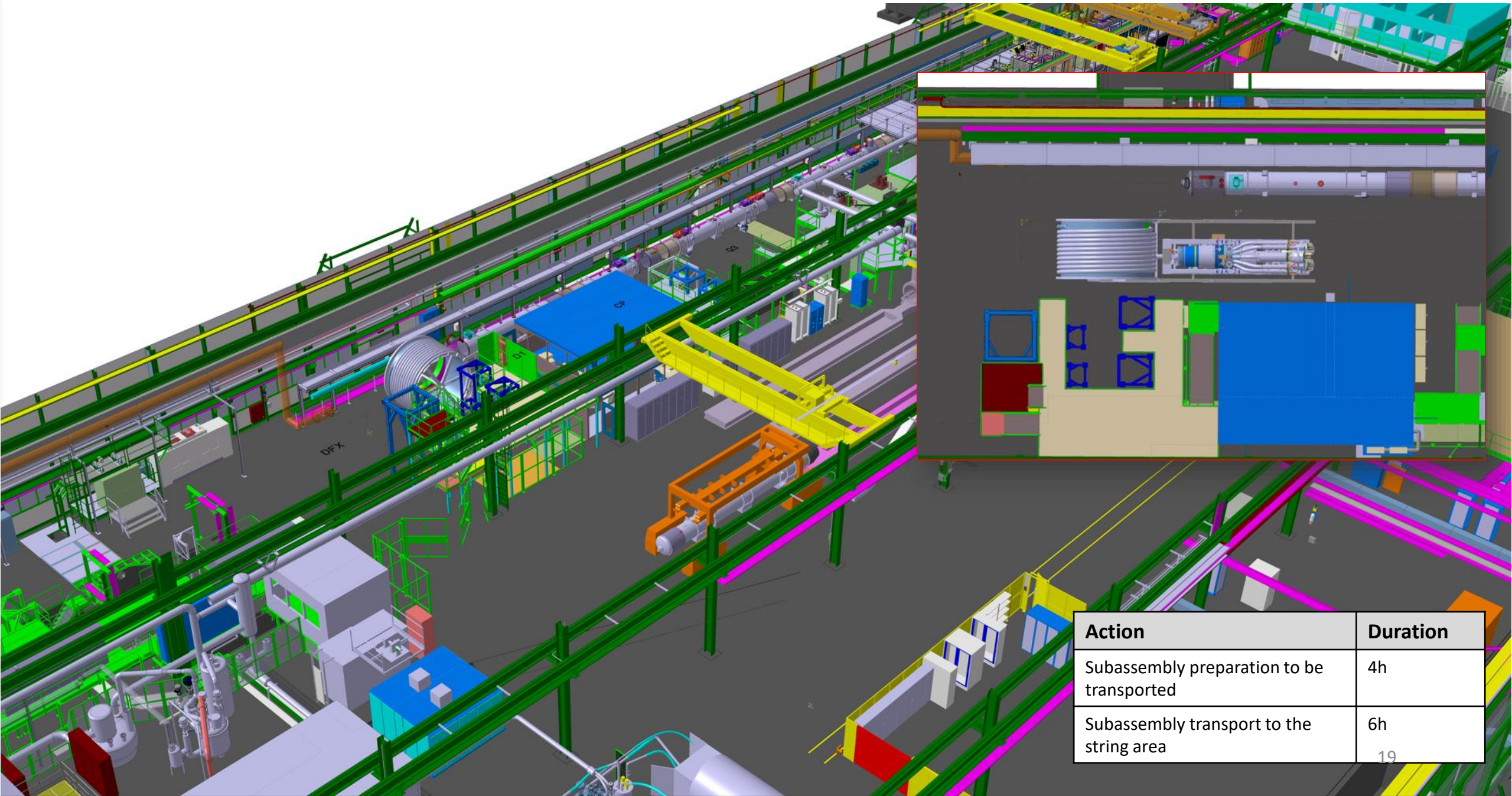
# Phase 0: DFHx-SCLink subassembly transportation



Action	Duration
Subassembly preparation to be transported	4h
Subassembly transport to the string area	6h



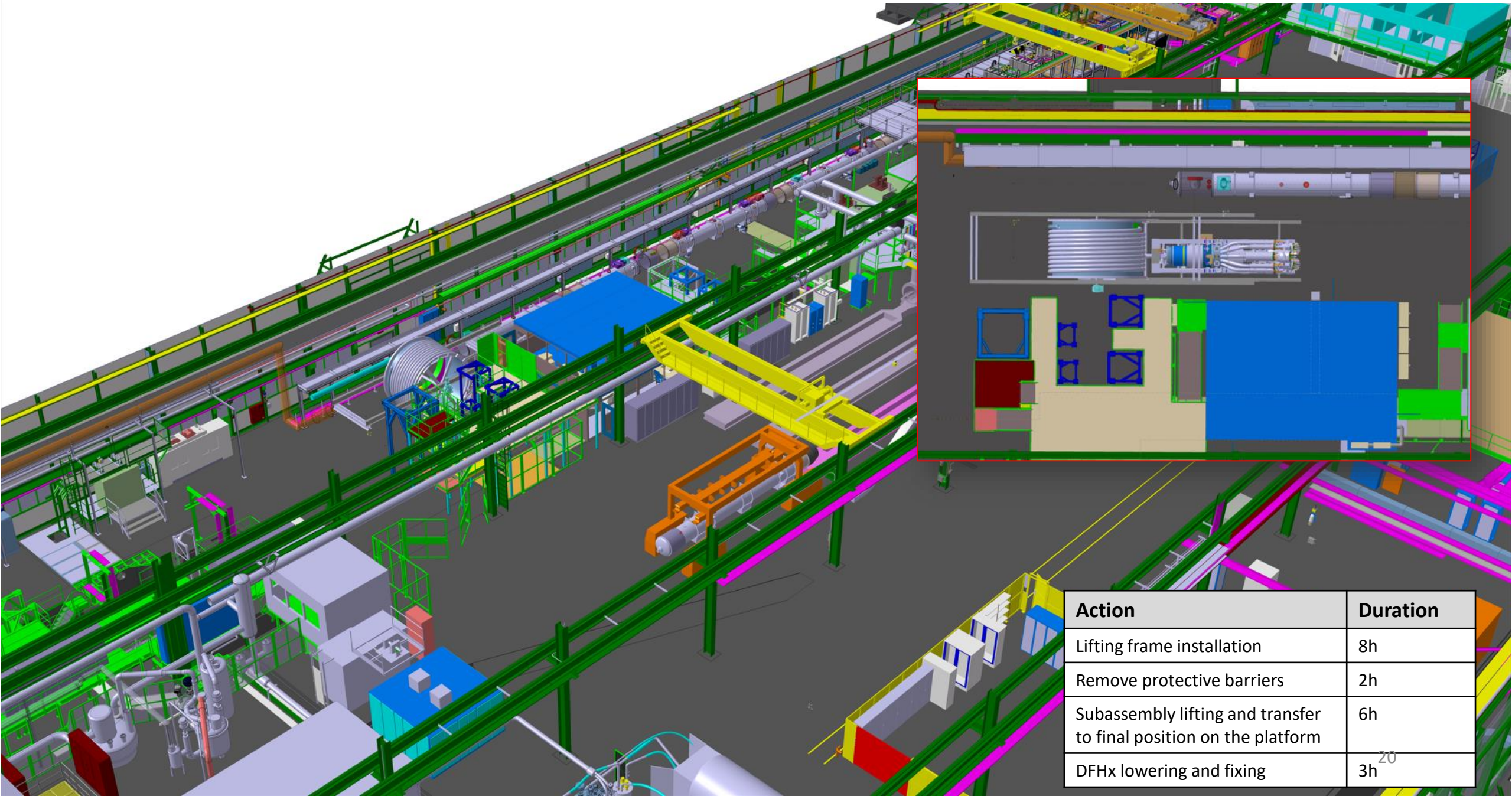
# Phase 0: DFHx-SCLink subassembly transportation



Action	Duration
Subassembly preparation to be transported	4h
Subassembly transport to the string area	6h



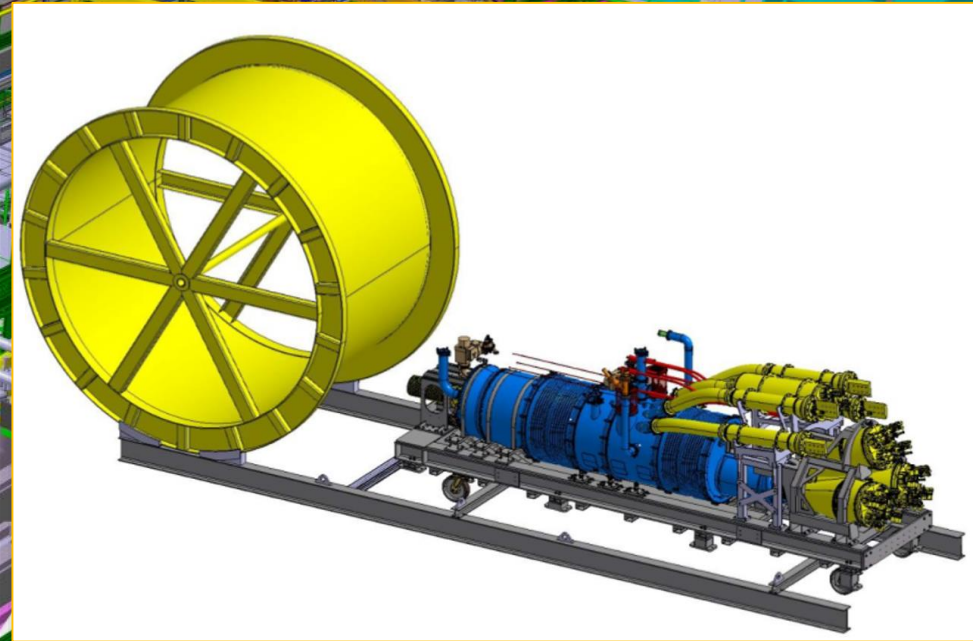
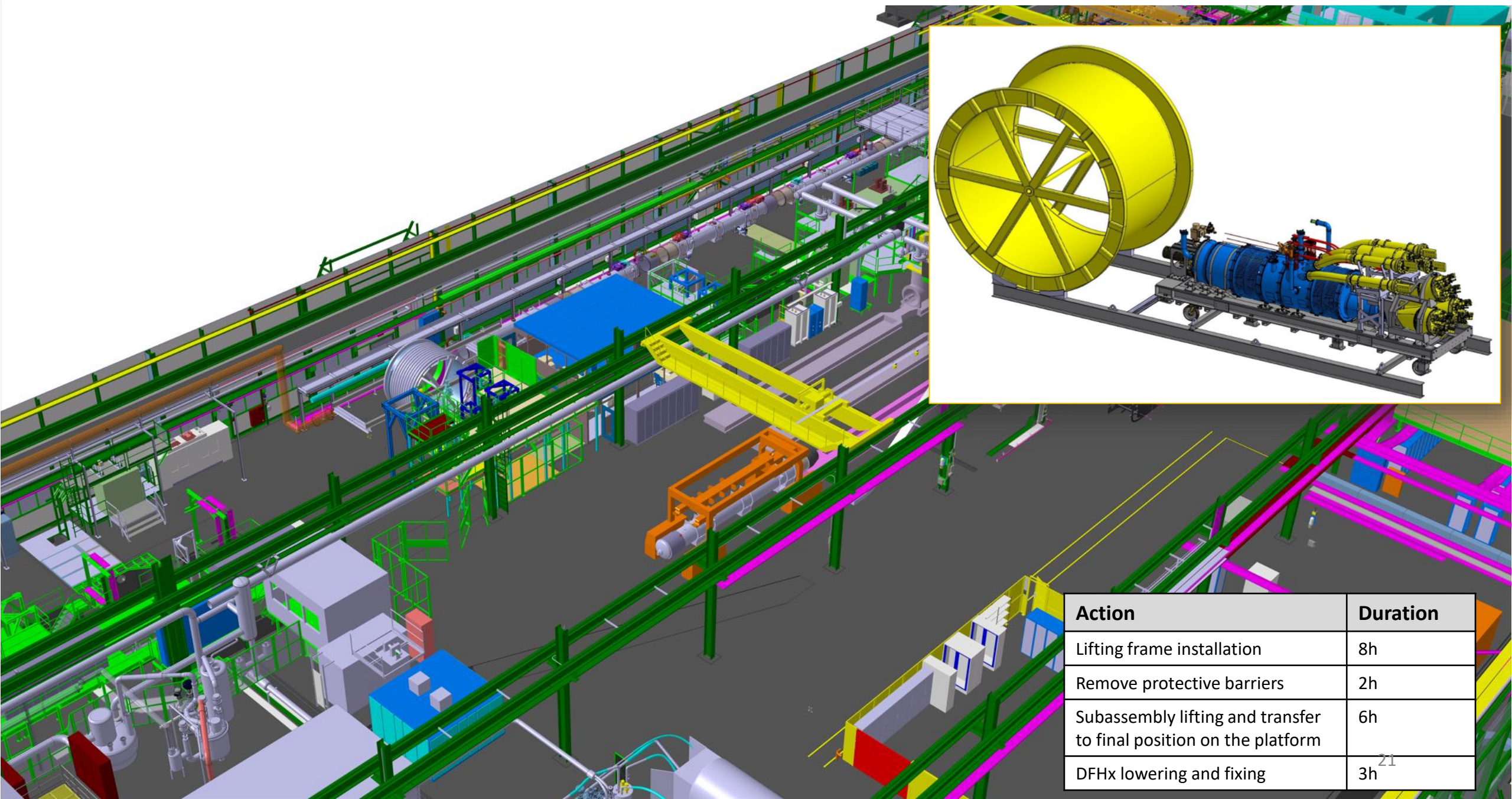
# Phase 1: DFHx-SCLink subassembly lifting and installation on the platform



Action	Duration
Lifting frame installation	8h
Remove protective barriers	2h
Subassembly lifting and transfer to final position on the platform	6h
DFHx lowering and fixing	3h



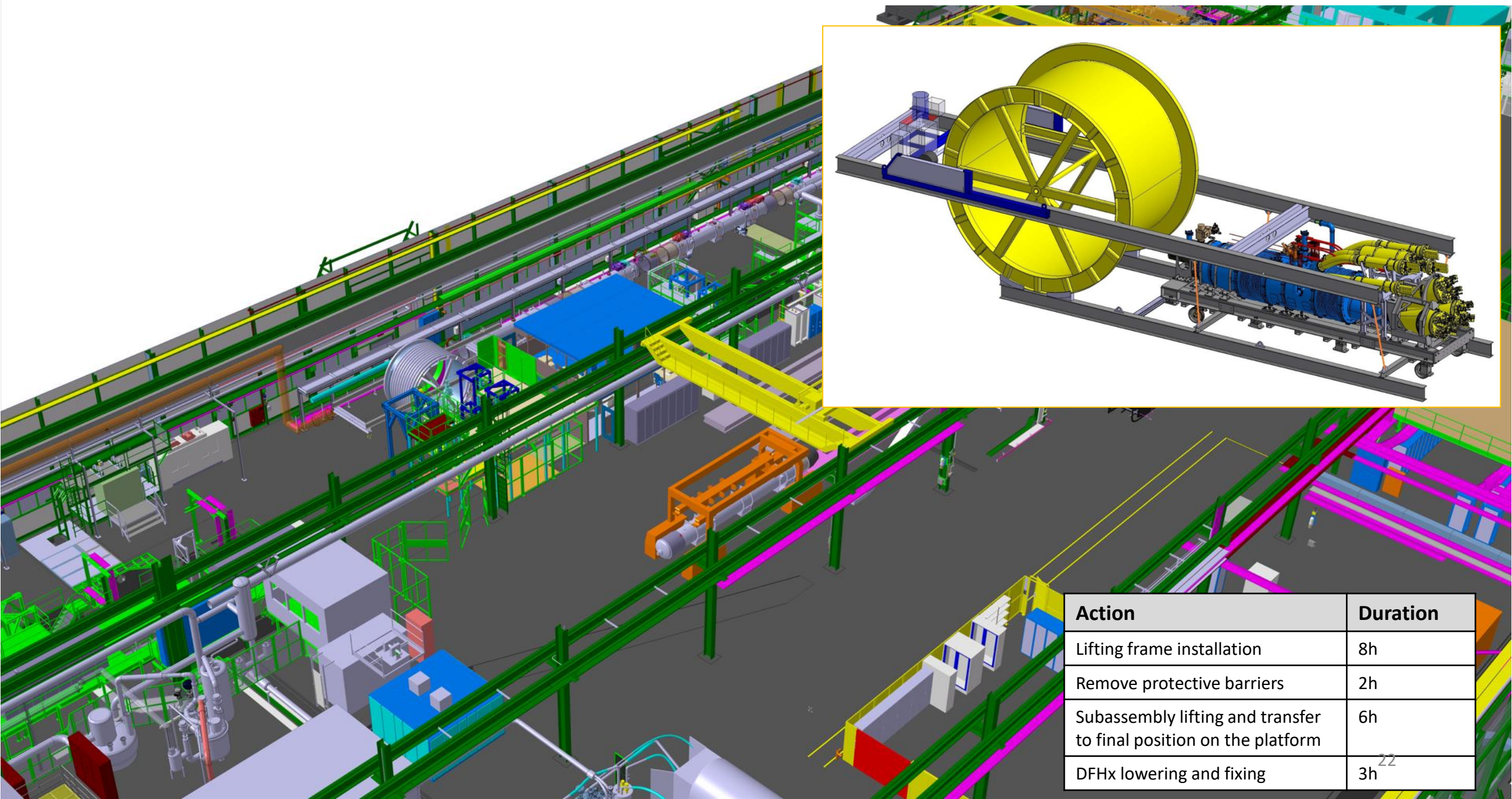
# Phase 1: DFHx-SCLink subassembly lifting and installation on the platform



Action	Duration
Lifting frame installation	8h
Remove protective barriers	2h
Subassembly lifting and transfer to final position on the platform	6h
DFHx lowering and fixing	3h



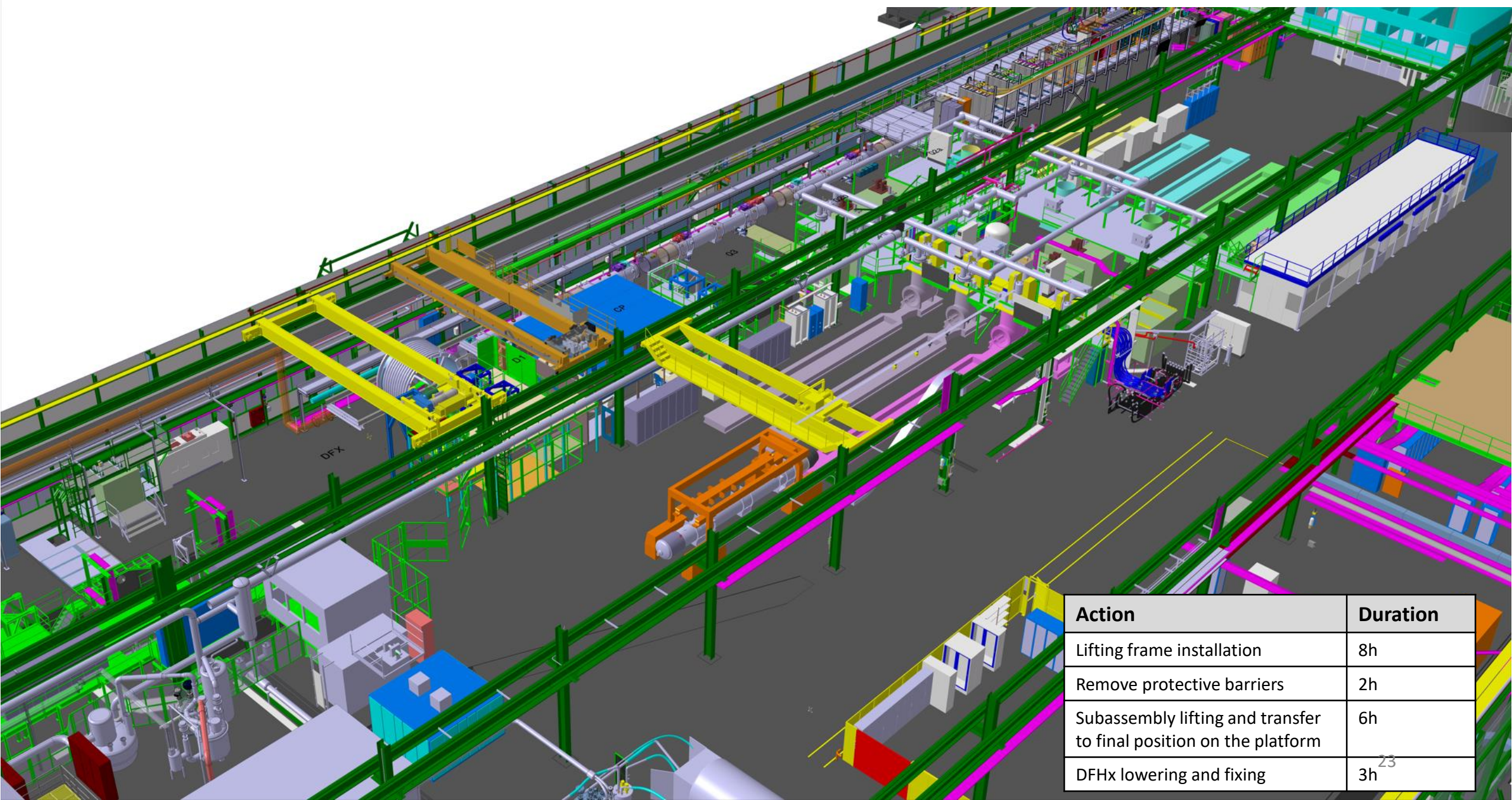
# Phase 1: DFHx-SCLink subassembly lifting and installation on the platform



Action	Duration
Lifting frame installation	8h
Remove protective barriers	2h
Subassembly lifting and transfer to final position on the platform	6h
DFHx lowering and fixing	3h



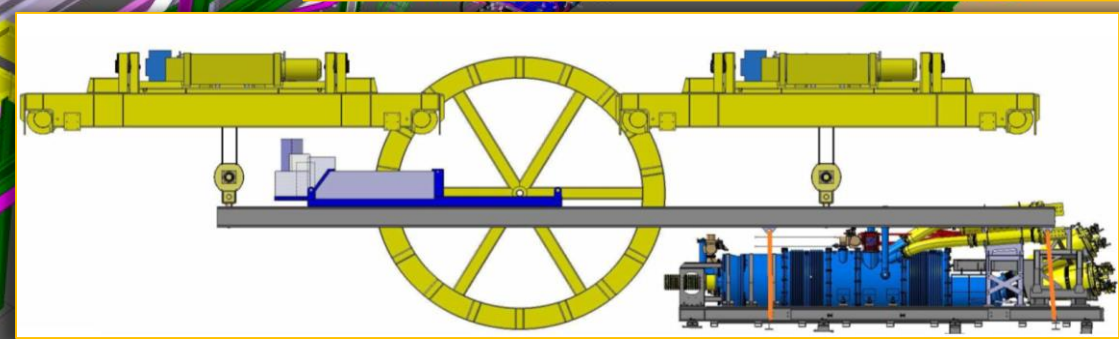
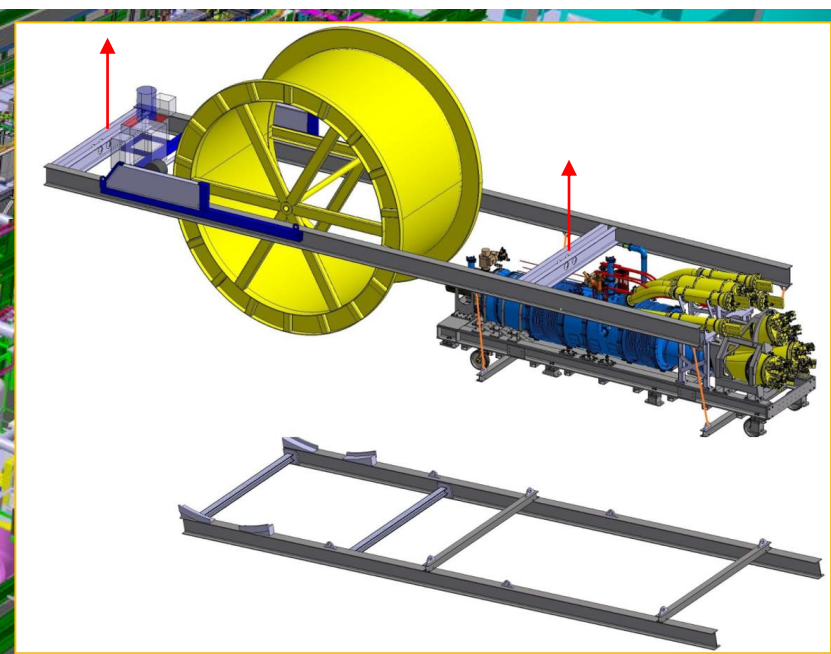
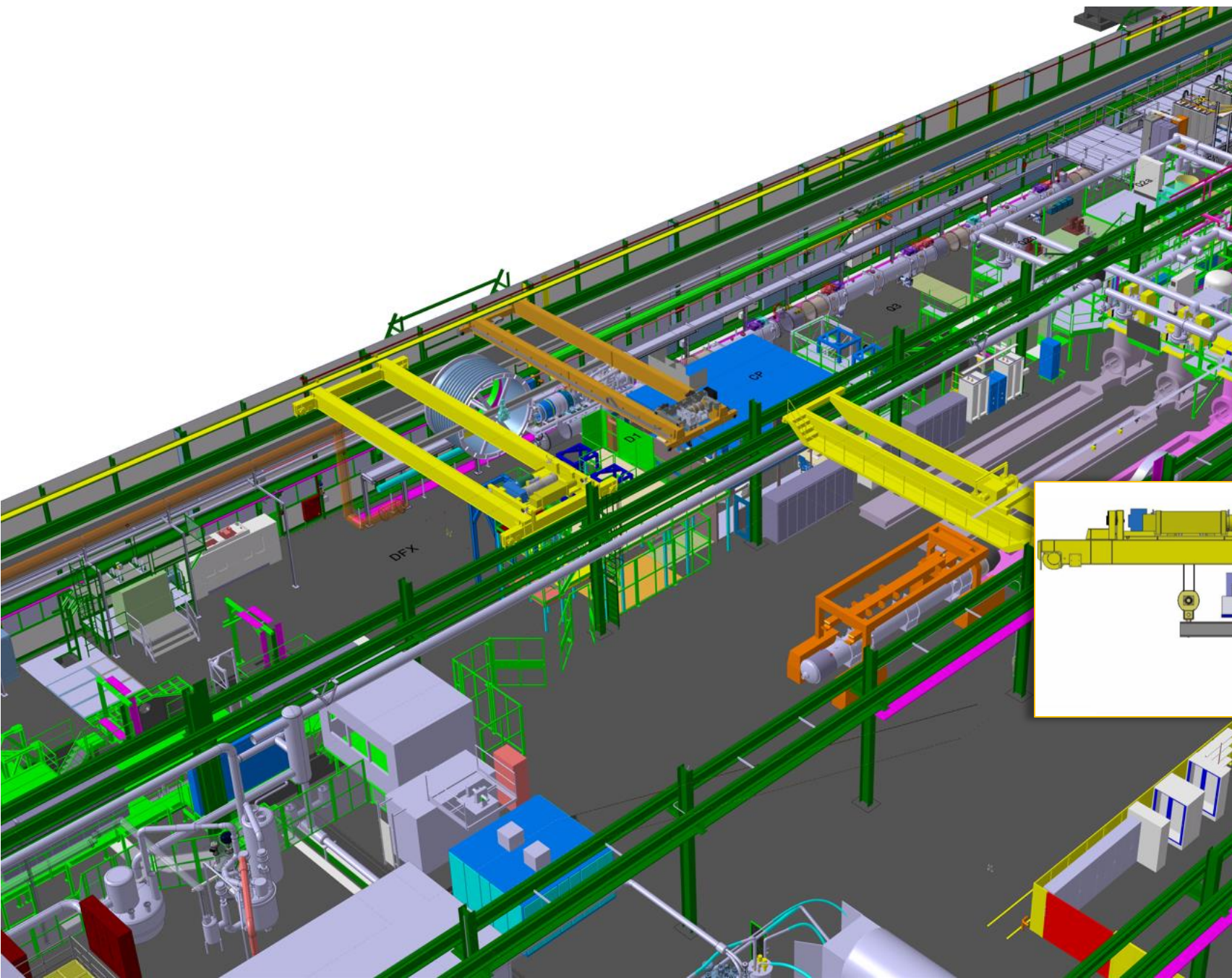
# Phase 1: DFHx-SCLink subassembly lifting and installation on the platform



Action	Duration
Lifting frame installation	8h
Remove protective barriers	2h
Subassembly lifting and transfer to final position on the platform	6h
DFHx lowering and fixing	3h



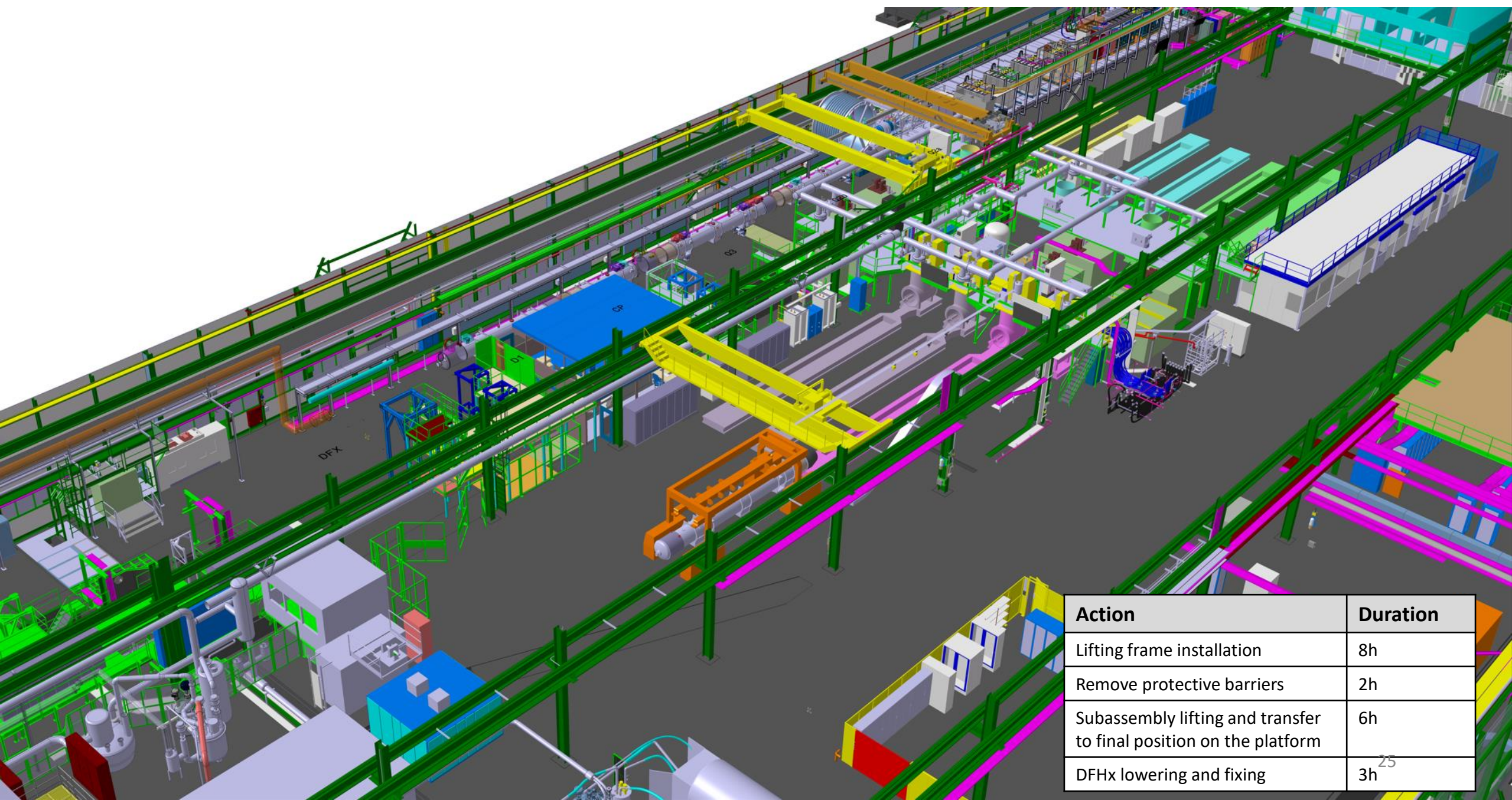
# Phase 1: DFHx-SCLink subassembly lifting and installation on the platform



Action	Duration
Lifting frame installation	8h
Remove protective barriers	2h
Subassembly lifting and transfer to final position on the platform	6h
DFHx lowering and fixing	3h



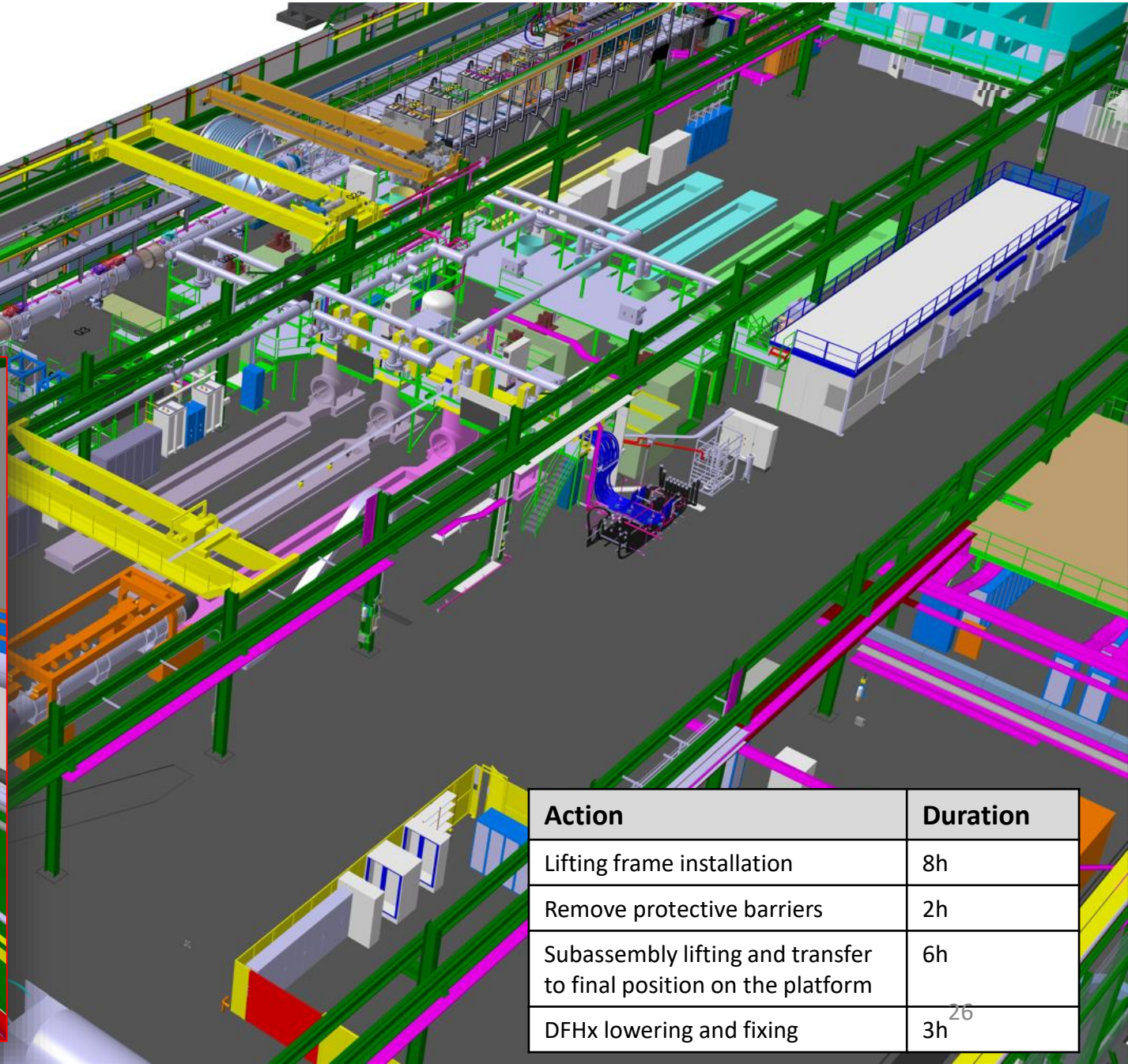
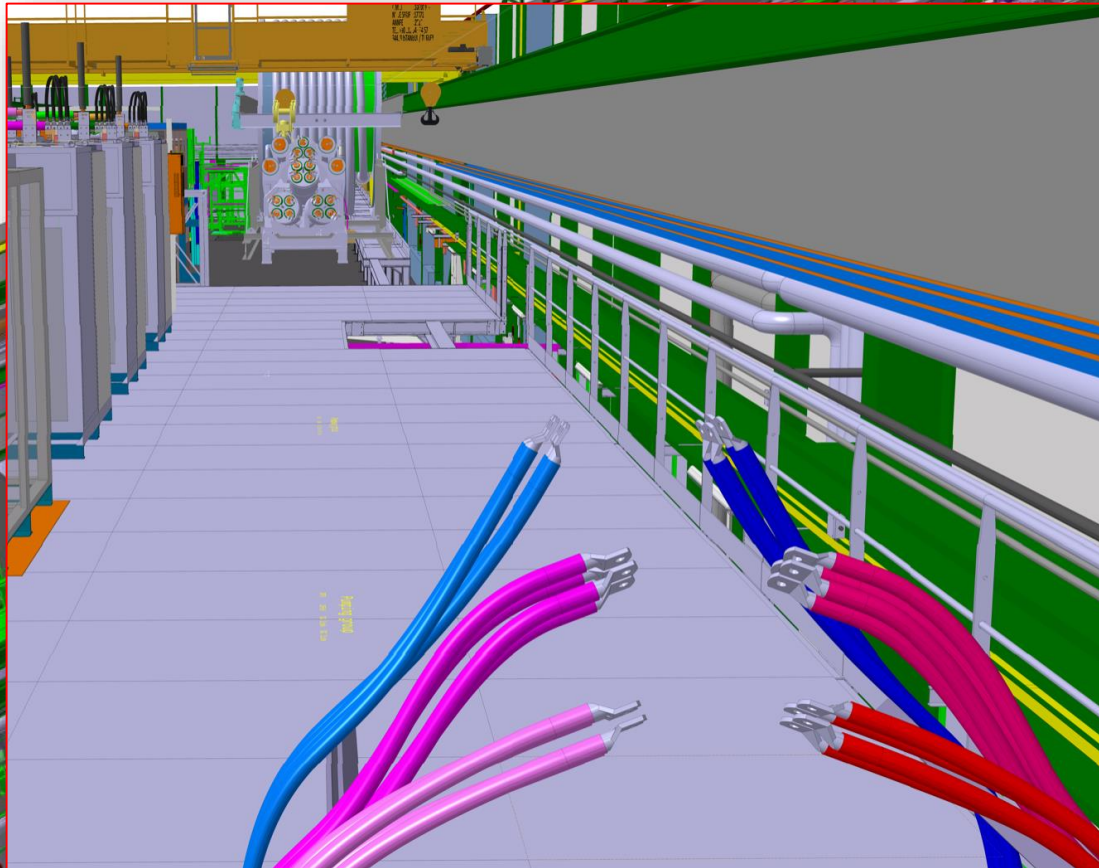
# Phase 1: DFHx-SCLink subassembly lifting and installation on the platform



Action	Duration
Lifting frame installation	8h
Remove protective barriers	2h
Subassembly lifting and transfer to final position on the platform	6h
DFHx lowering and fixing	3h



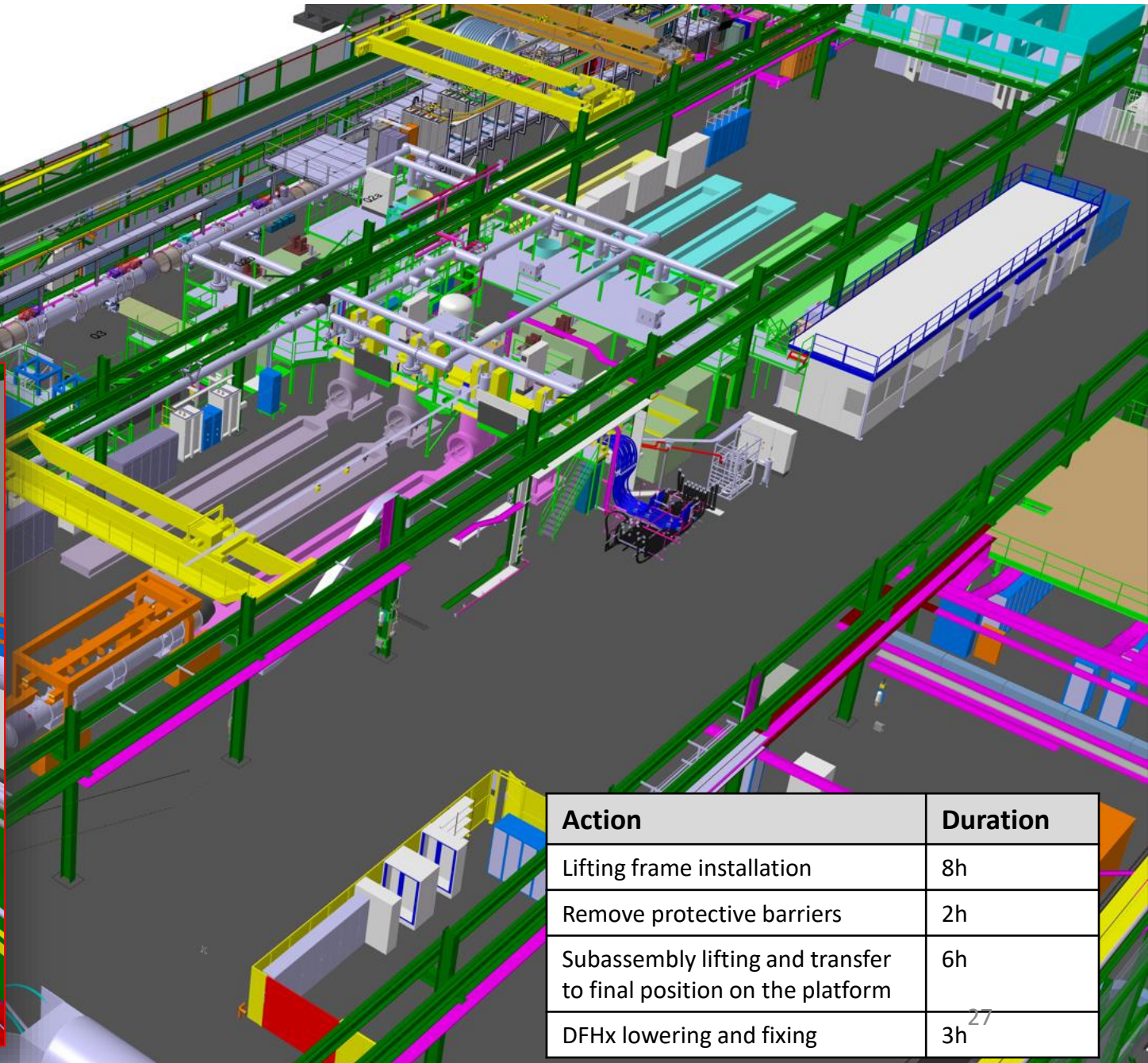
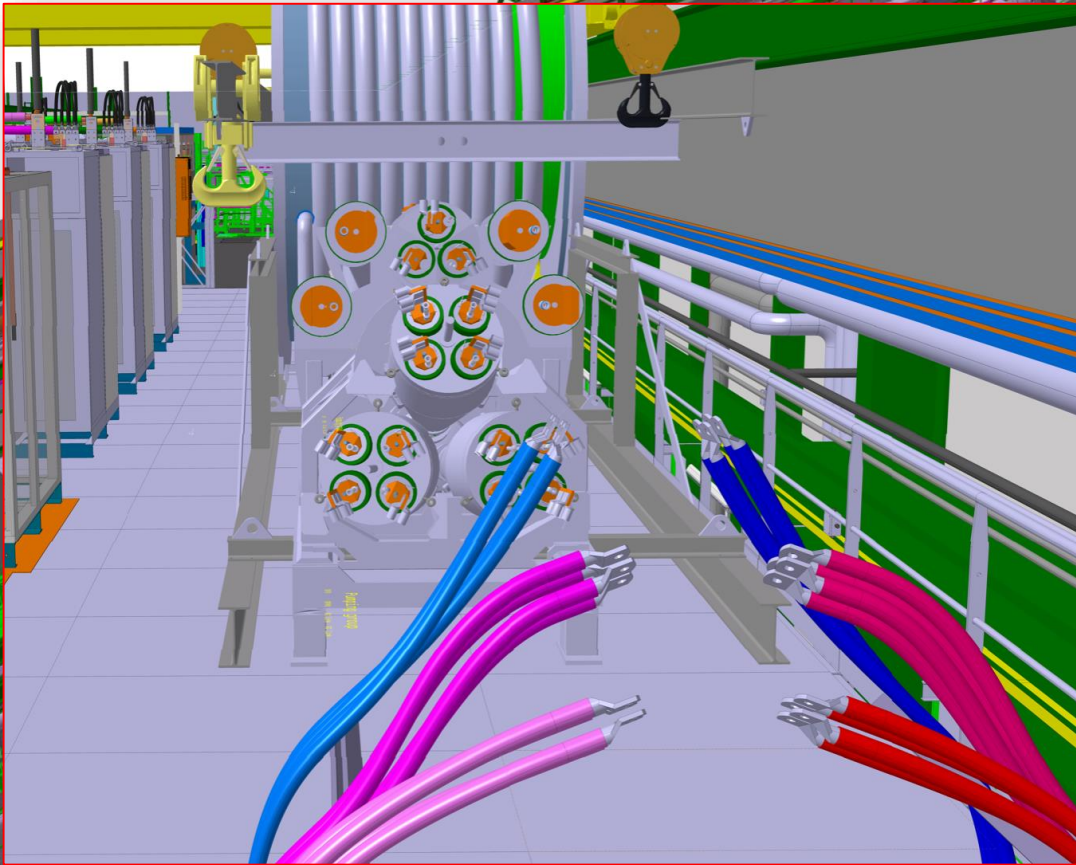
# Phase 1: DFHx-SCLink subassembly lifting and installation on the platform



Action	Duration
Lifting frame installation	8h
Remove protective barriers	2h
Subassembly lifting and transfer to final position on the platform	6h
DFHx lowering and fixing	3h



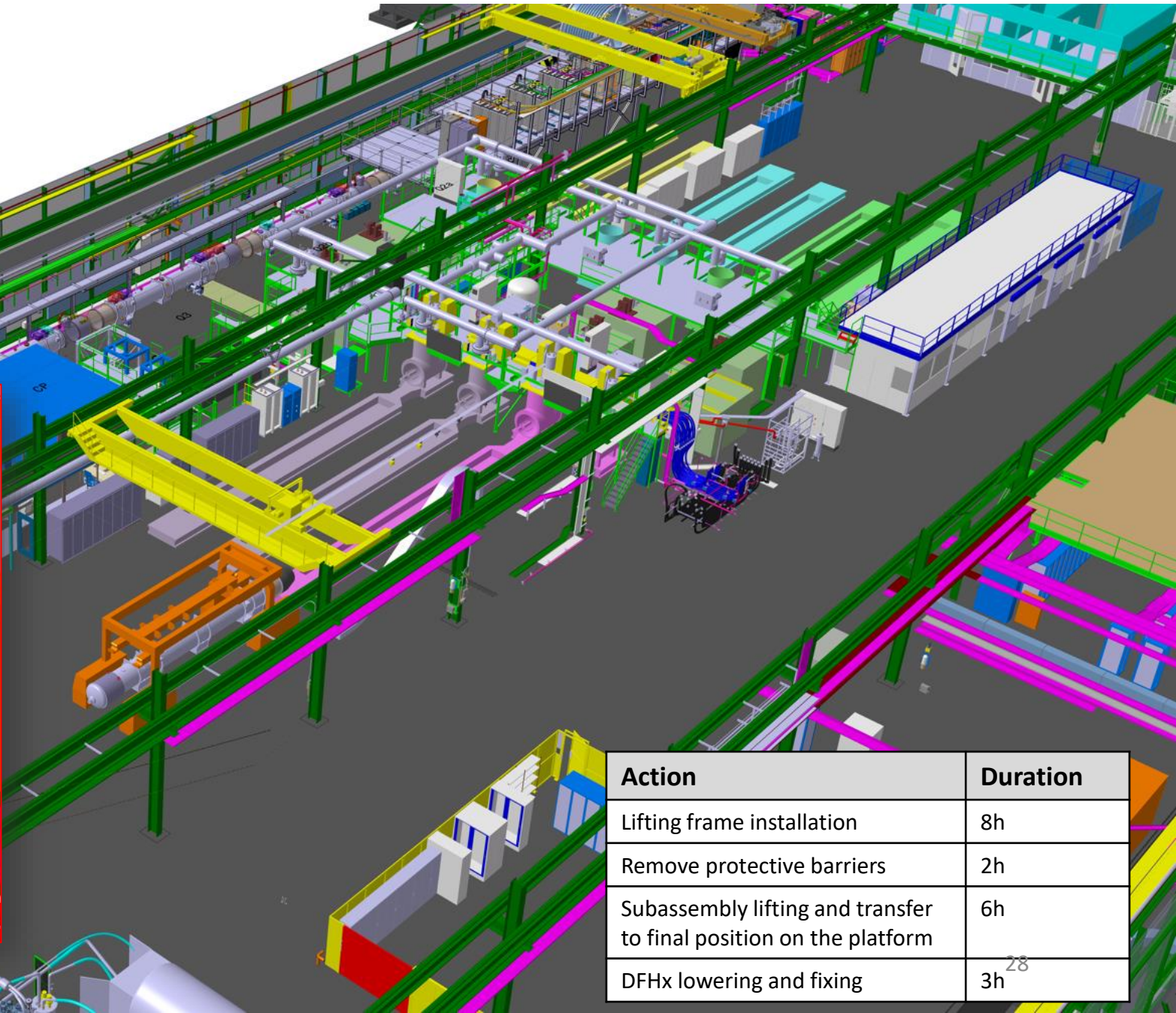
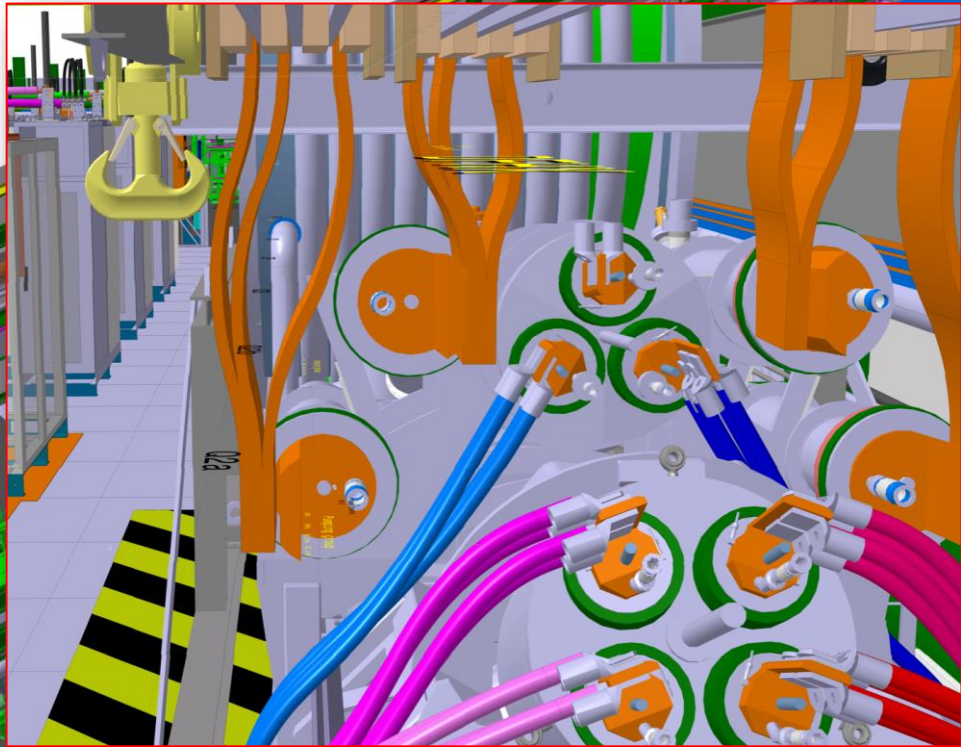
# Phase 1: DFHx-SCLink subassembly lifting and installation on the platform



Action	Duration
Lifting frame installation	8h
Remove protective barriers	2h
Subassembly lifting and transfer to final position on the platform	6h
DFHx lowering and fixing	3h



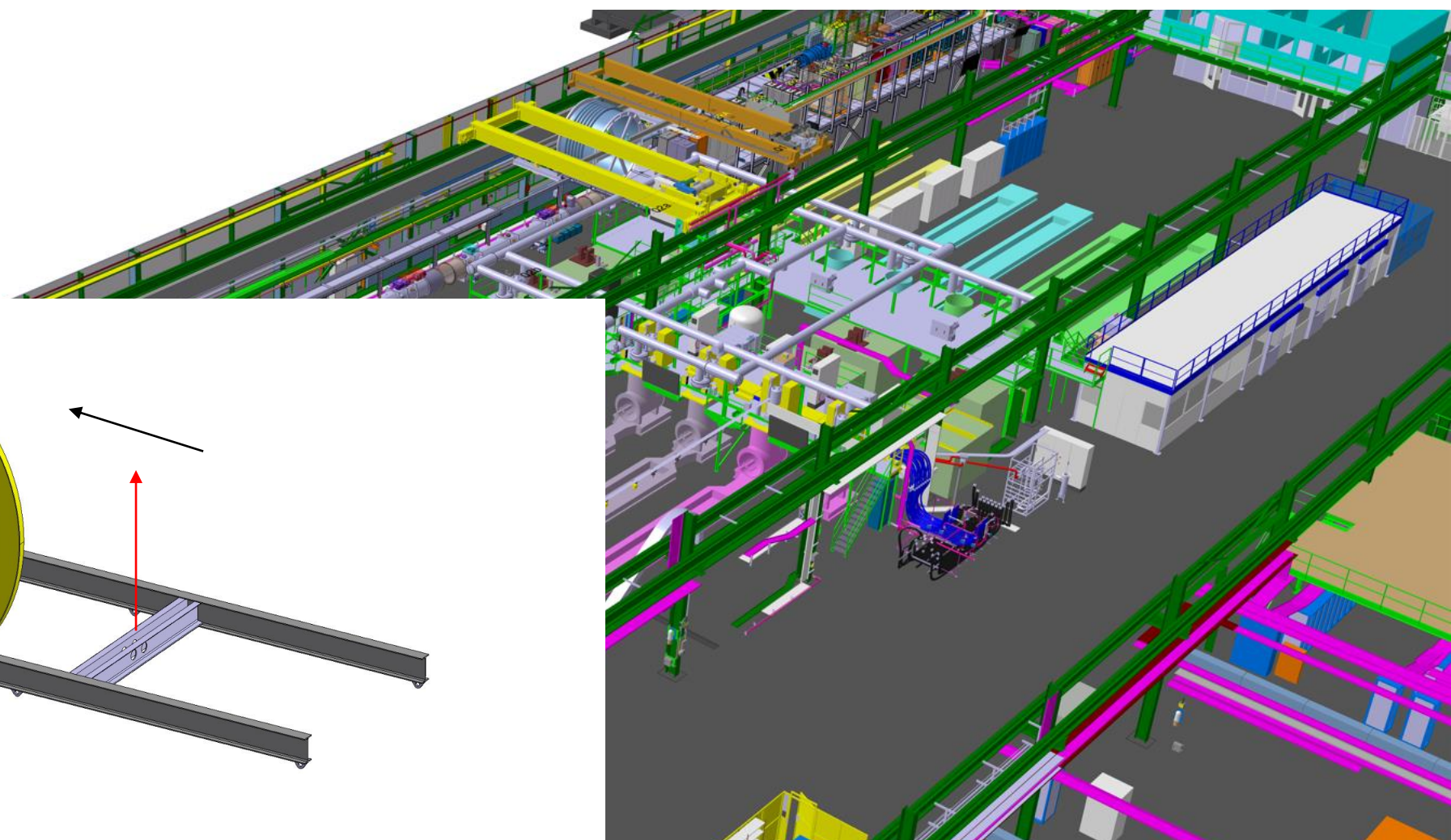
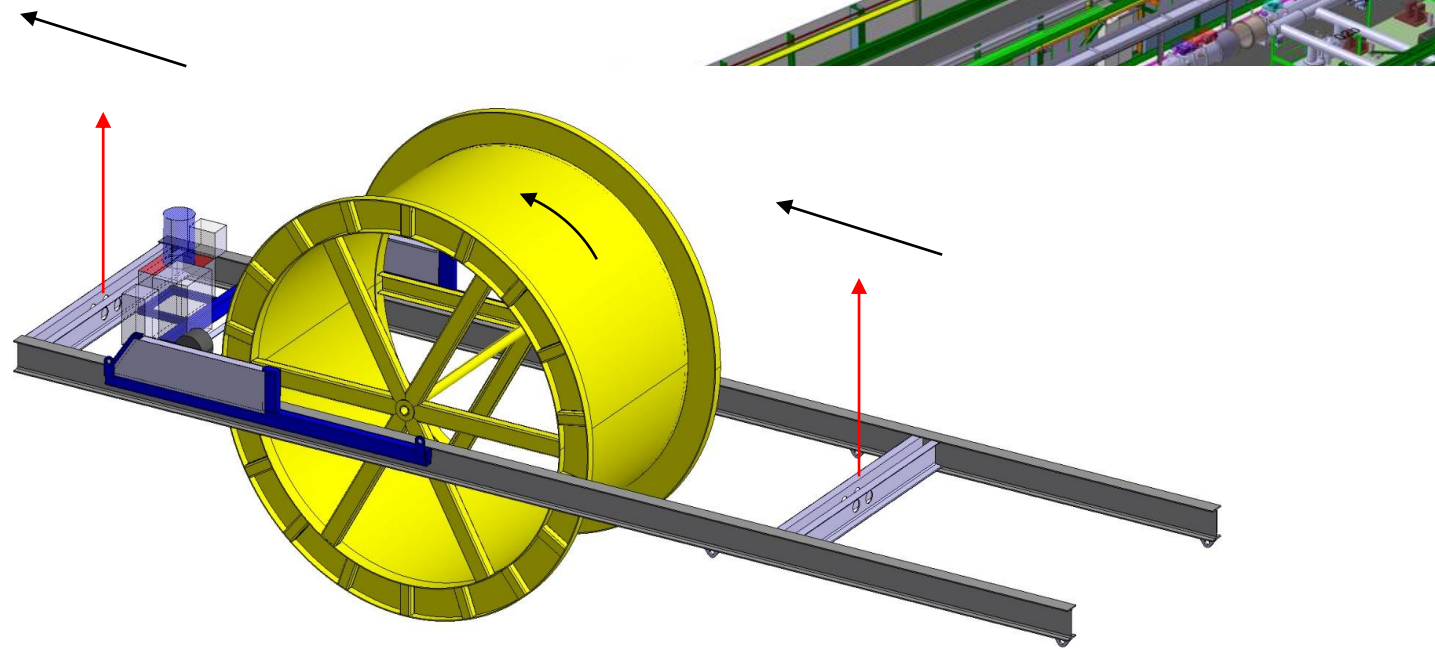
# Phase 1: DFHx-SCLink subassembly lifting and installation on the platform



Action	Duration
Lifting frame installation	8h
Remove protective barriers	2h
Subassembly lifting and transfer to final position on the platform	6h
DFHx lowering and fixing	3h



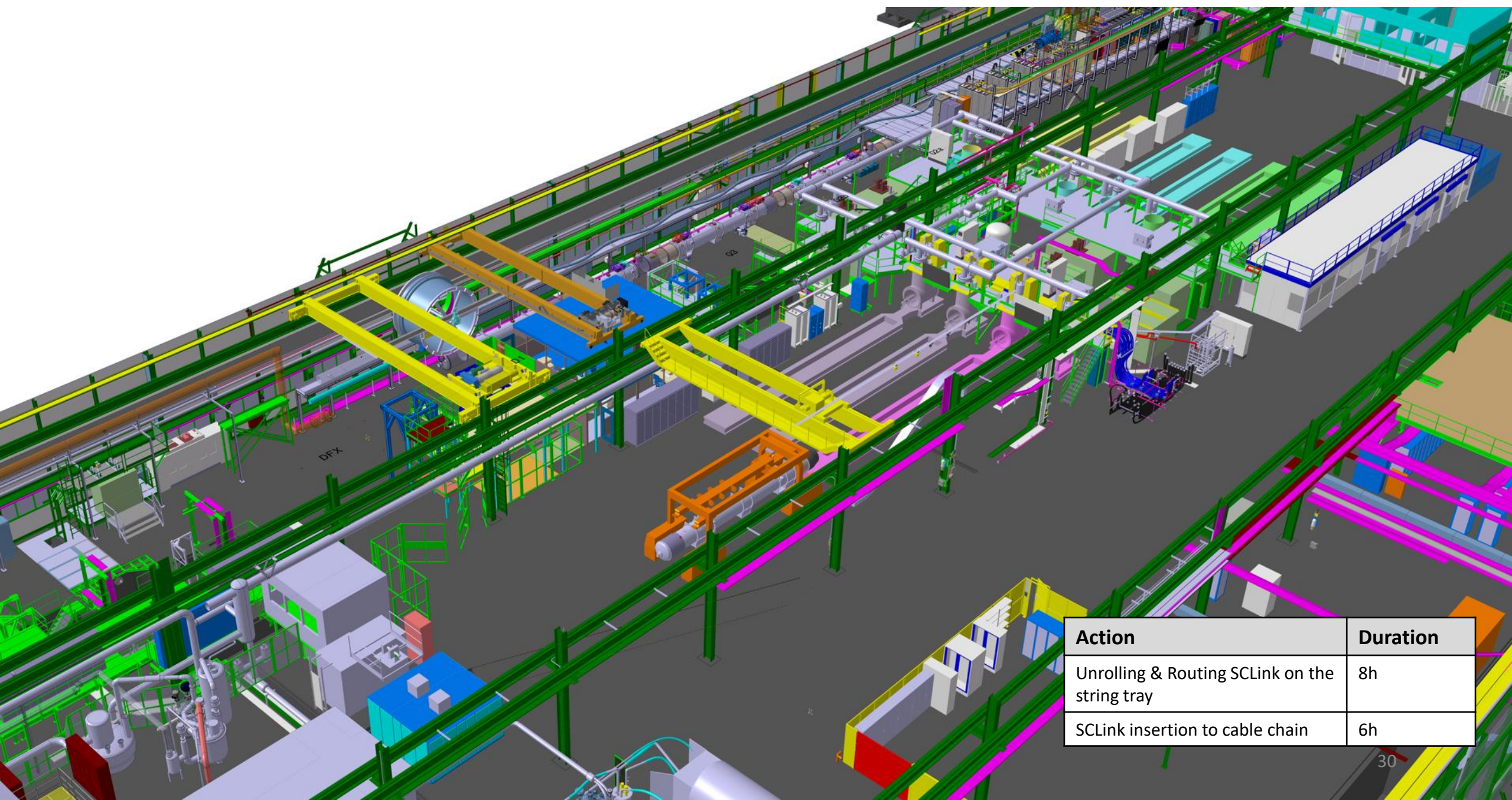
# Phase 2: SCLink unrolling



Action	Duration
Unrolling & Routing SCLink on the string tray	8h
SCLink insertion to cable chain	6h



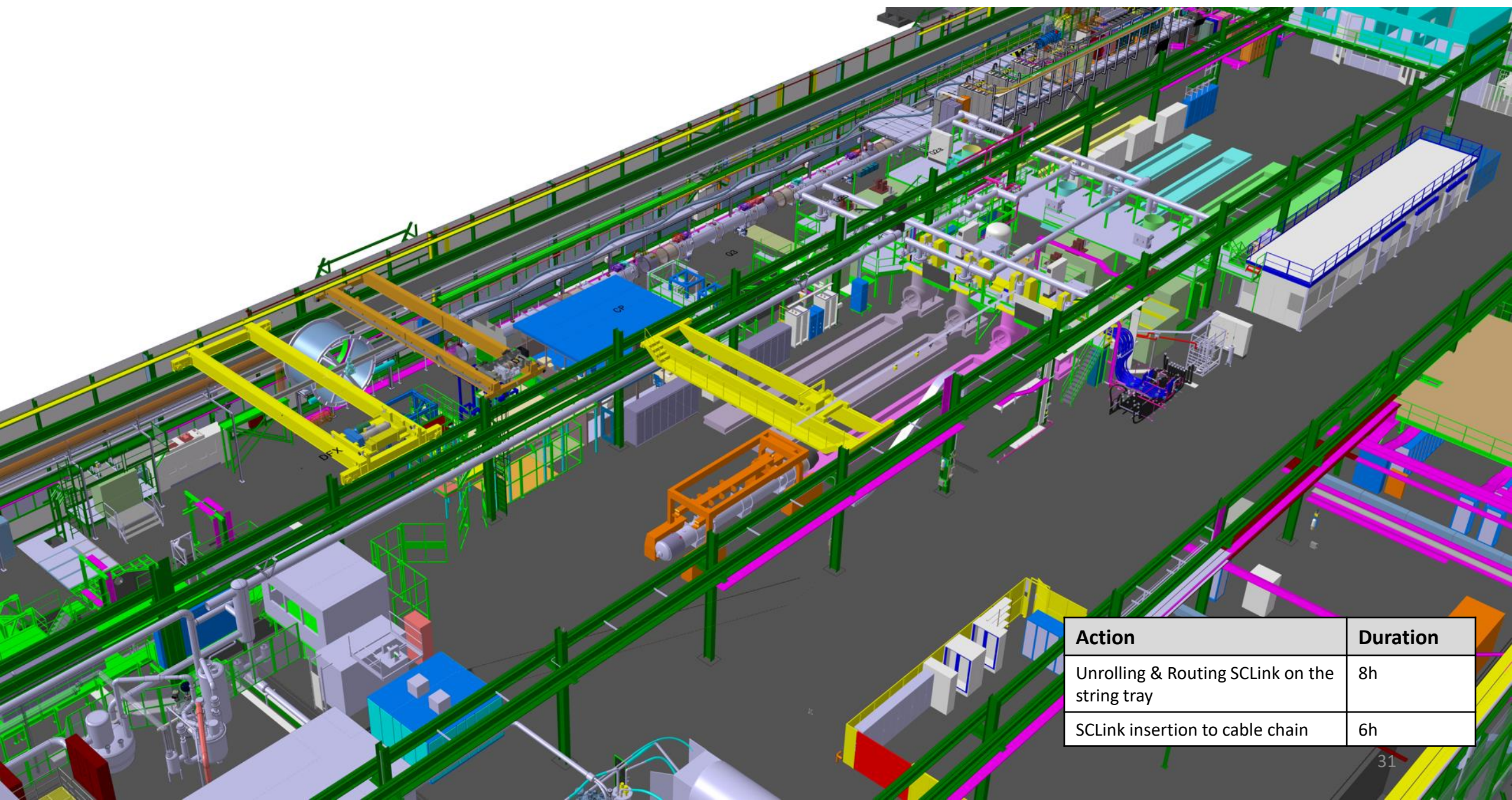
# Phase 2: SCLink unrolling



Action	Duration
Unrolling & Routing SCLink on the string tray	8h
SCLink insertion to cable chain	6h



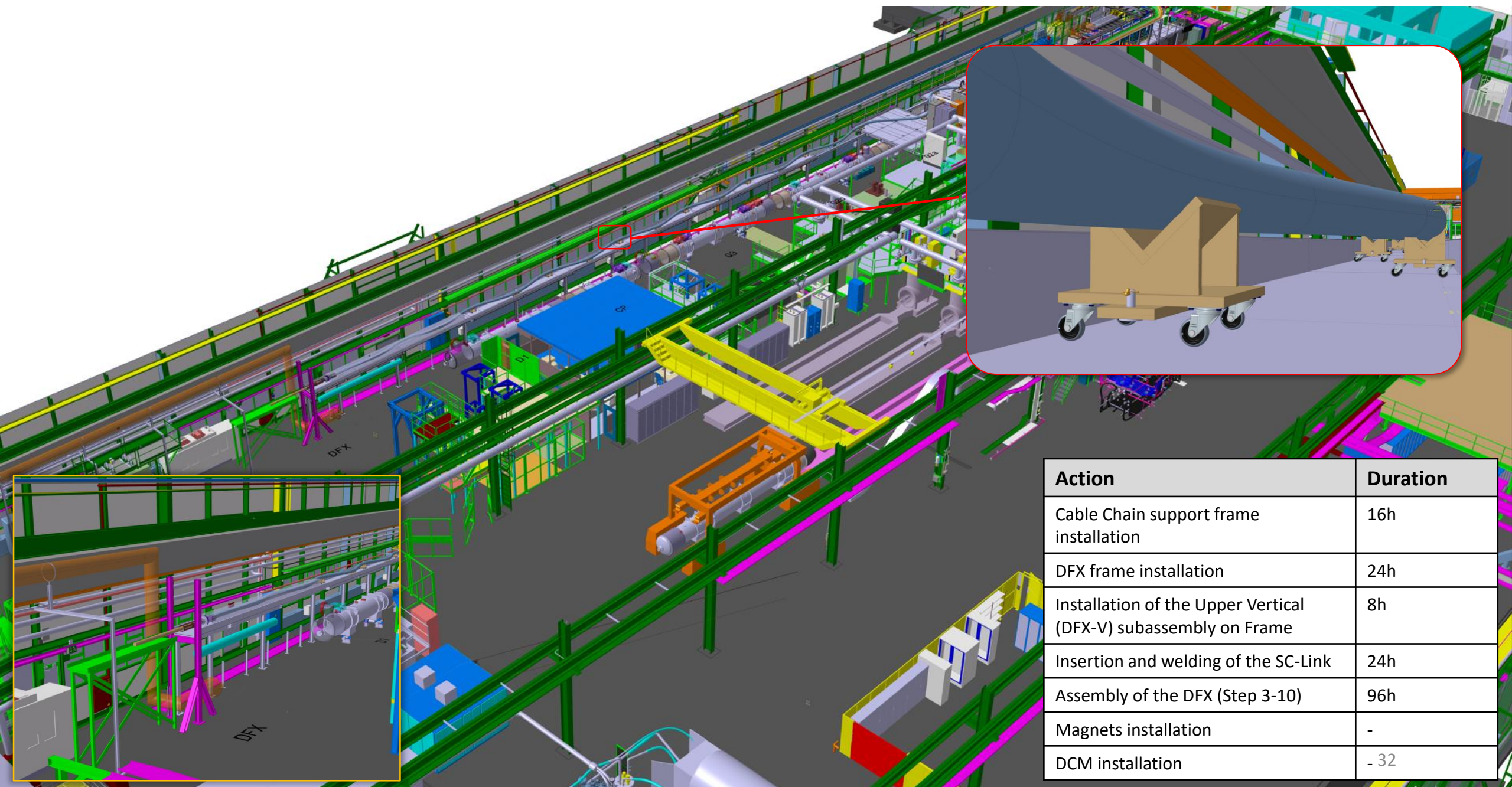
# Phase 2: SCLink unrolling



Action	Duration
Unrolling & Routing SCLink on the string tray	8h
SCLink insertion to cable chain	6h



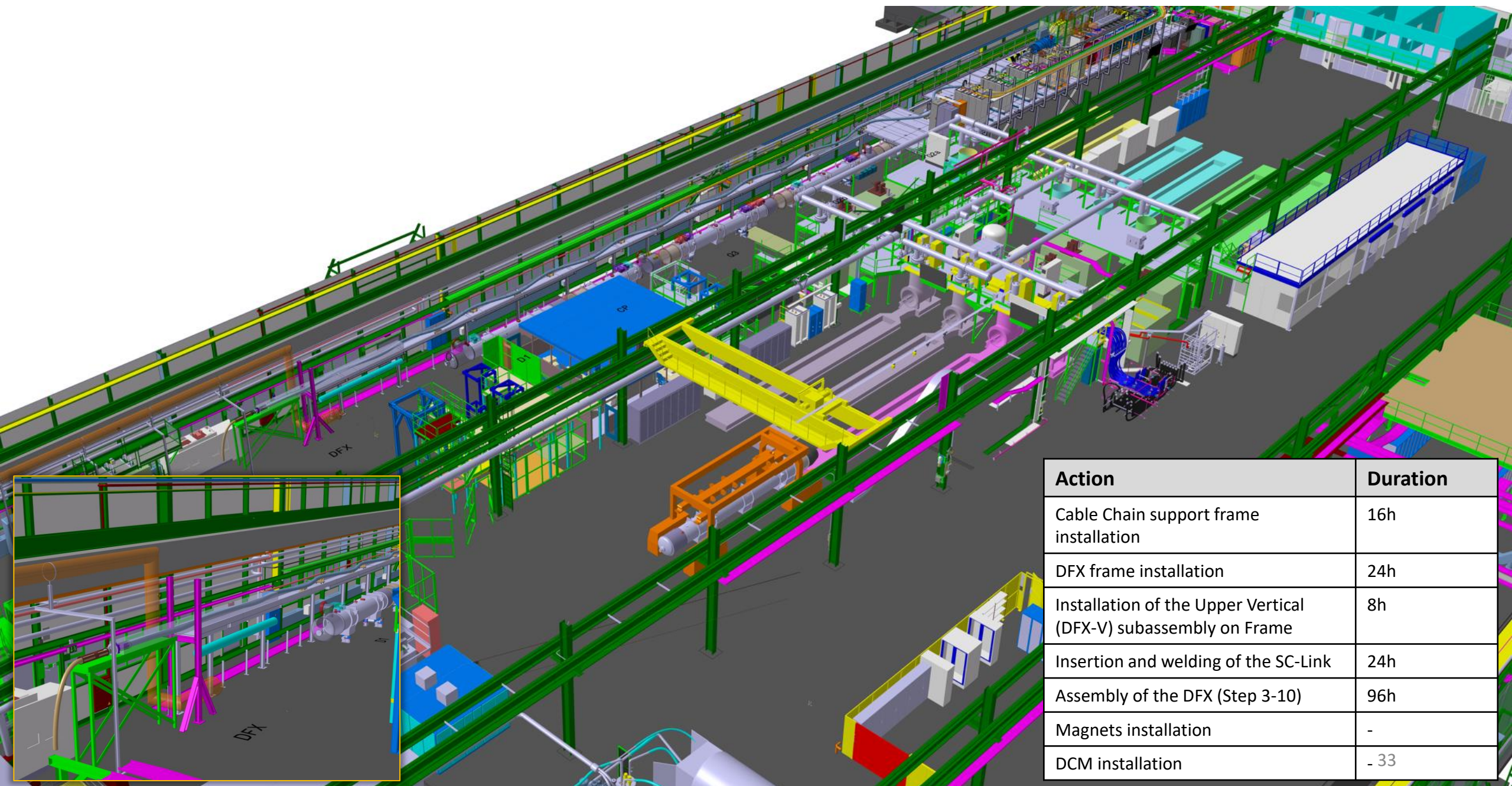
# Phase 3: DFX assembly and NbTi extremity installation



Action	Duration
Cable Chain support frame installation	16h
DFX frame installation	24h
Installation of the Upper Vertical (DFX-V) subassembly on Frame	8h
Insertion and welding of the SC-Link	24h
Assembly of the DFX (Step 3-10)	96h
Magnets installation	-
DCM installation	- 32



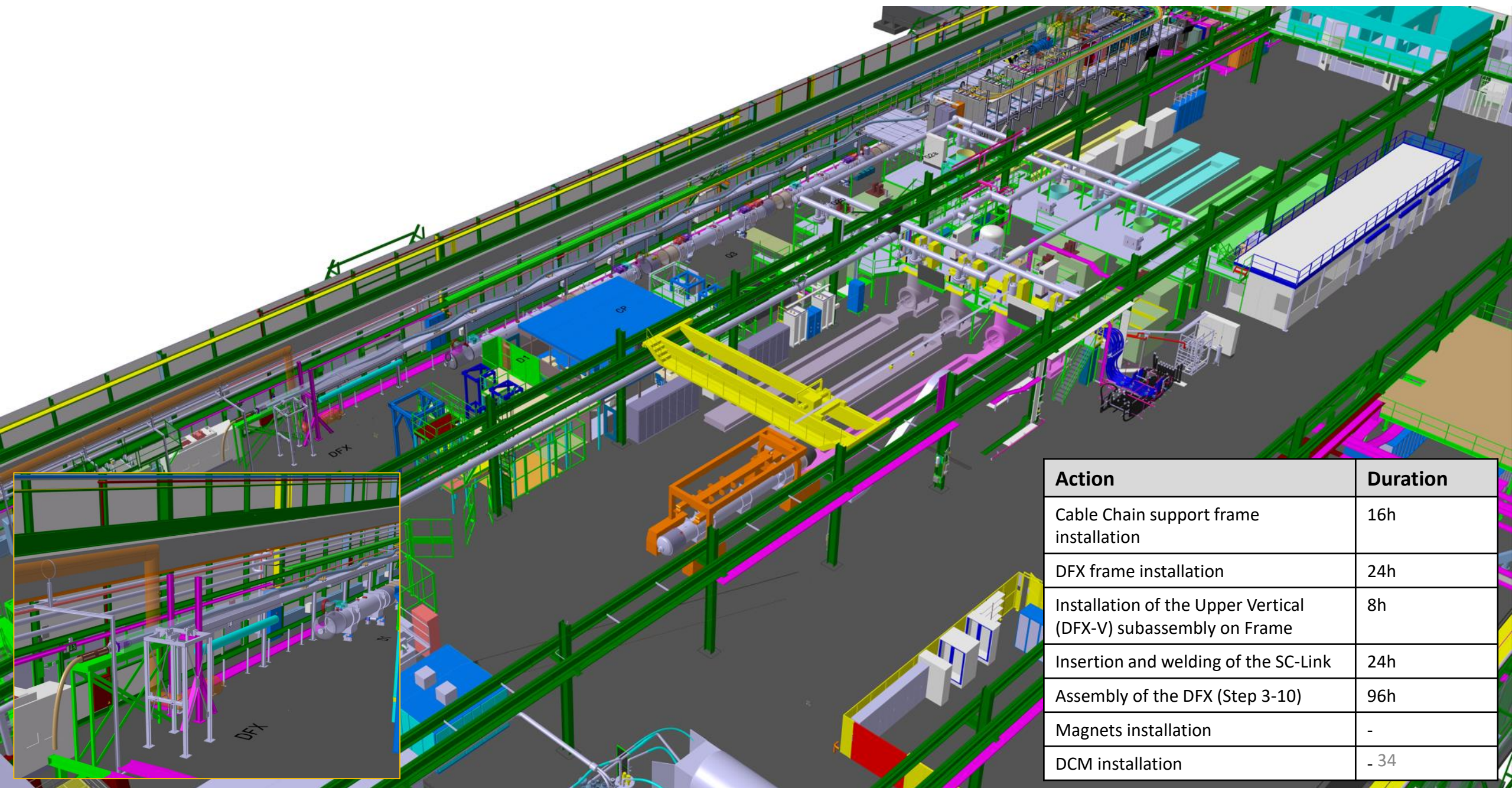
# Phase 3: DFX assembly and NbTi extremity installation



Action	Duration
Cable Chain support frame installation	16h
DFX frame installation	24h
Installation of the Upper Vertical (DFX-V) subassembly on Frame	8h
Insertion and welding of the SC-Link	24h
Assembly of the DFX (Step 3-10)	96h
Magnets installation	-
DCM installation	- 33



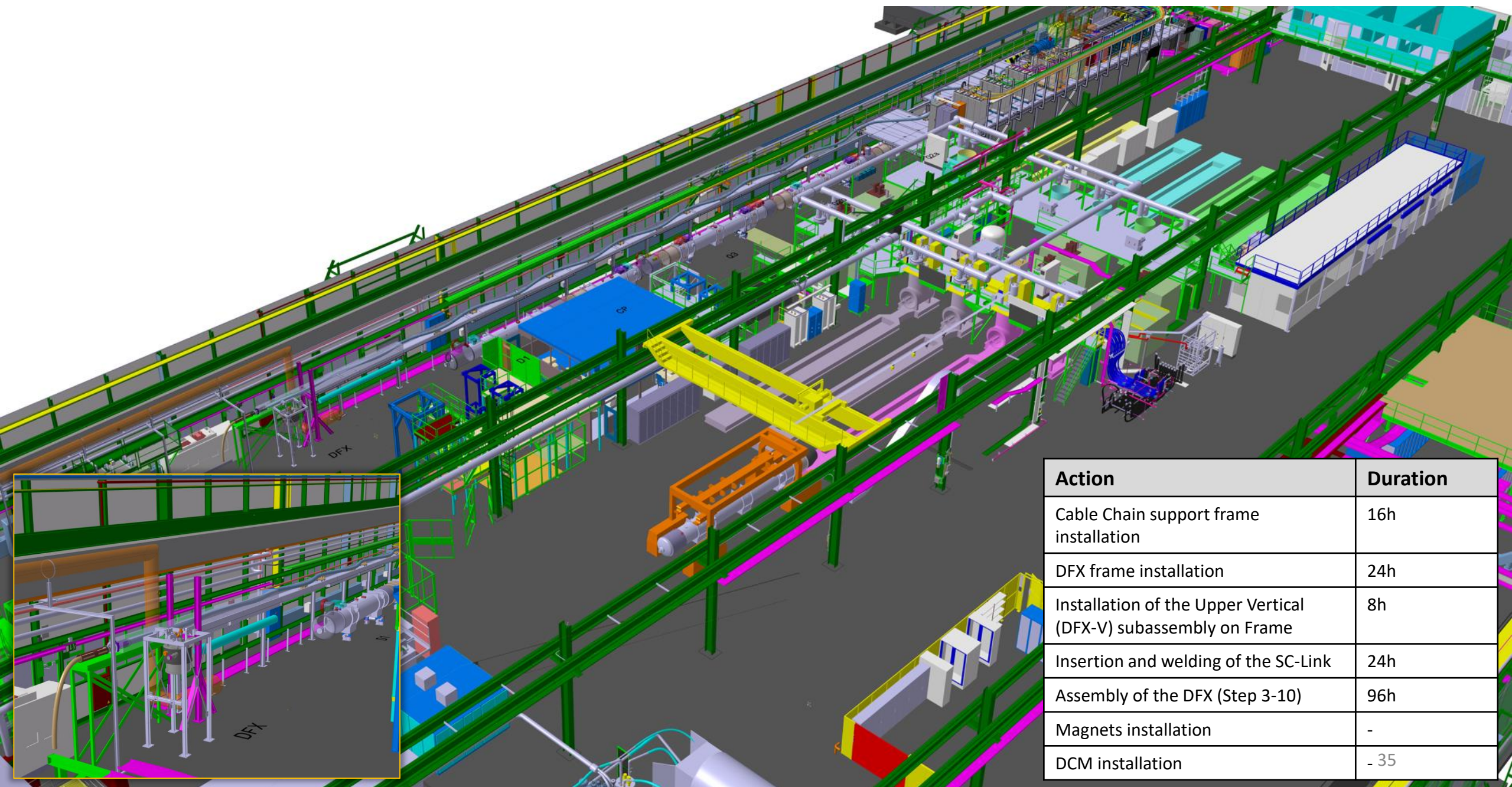
# Phase 3: DFX assembly and NbTi extremity installation



Action	Duration
Cable Chain support frame installation	16h
DFX frame installation	24h
Installation of the Upper Vertical (DFX-V) subassembly on Frame	8h
Insertion and welding of the SC-Link	24h
Assembly of the DFX (Step 3-10)	96h
Magnets installation	-
DCM installation	- 34



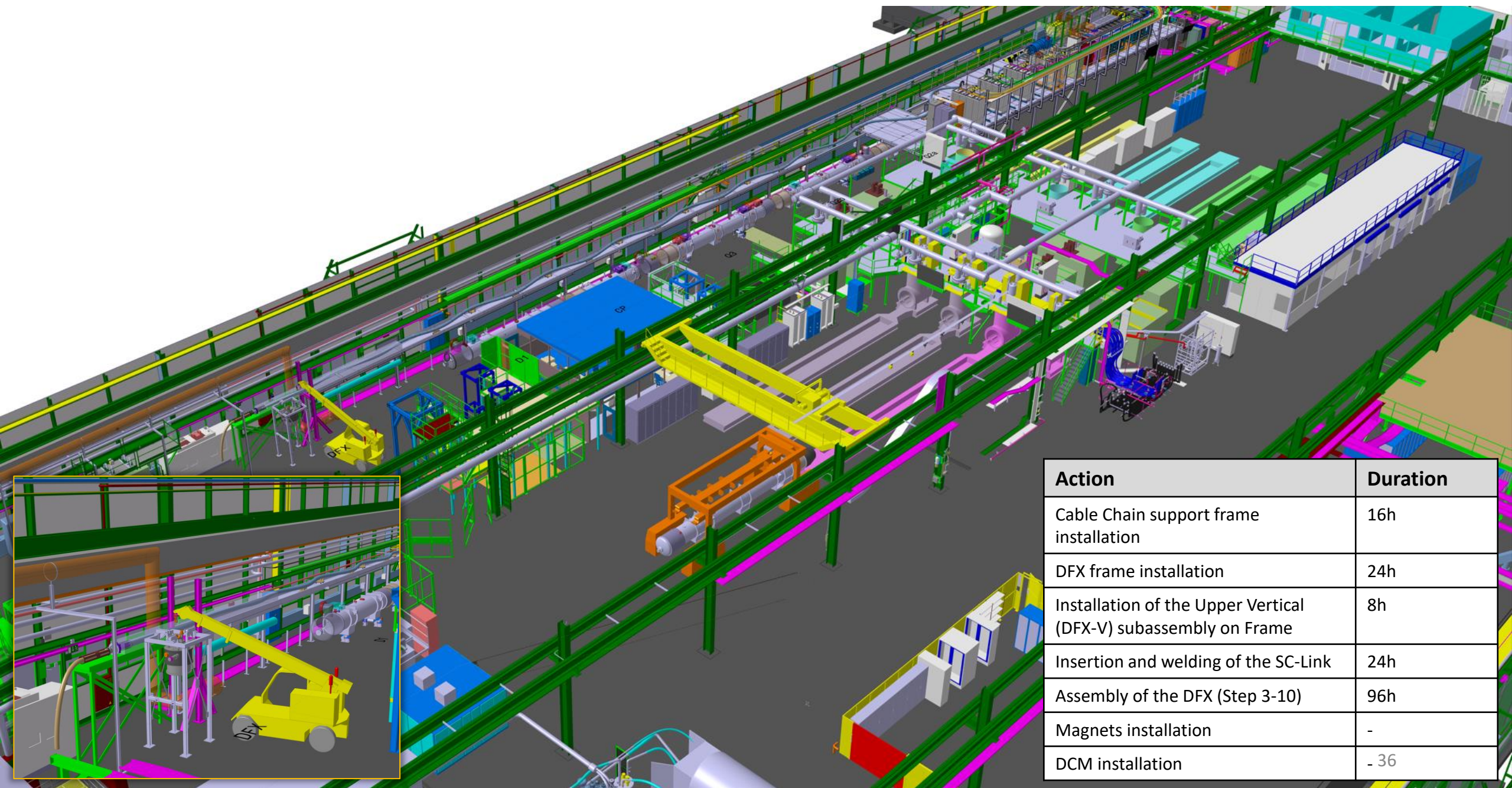
# Phase 3: DFX assembly and NbTi extremity installation



Action	Duration
Cable Chain support frame installation	16h
DFX frame installation	24h
Installation of the Upper Vertical (DFX-V) subassembly on Frame	8h
Insertion and welding of the SC-Link	24h
Assembly of the DFX (Step 3-10)	96h
Magnets installation	-
DCM installation	- 35



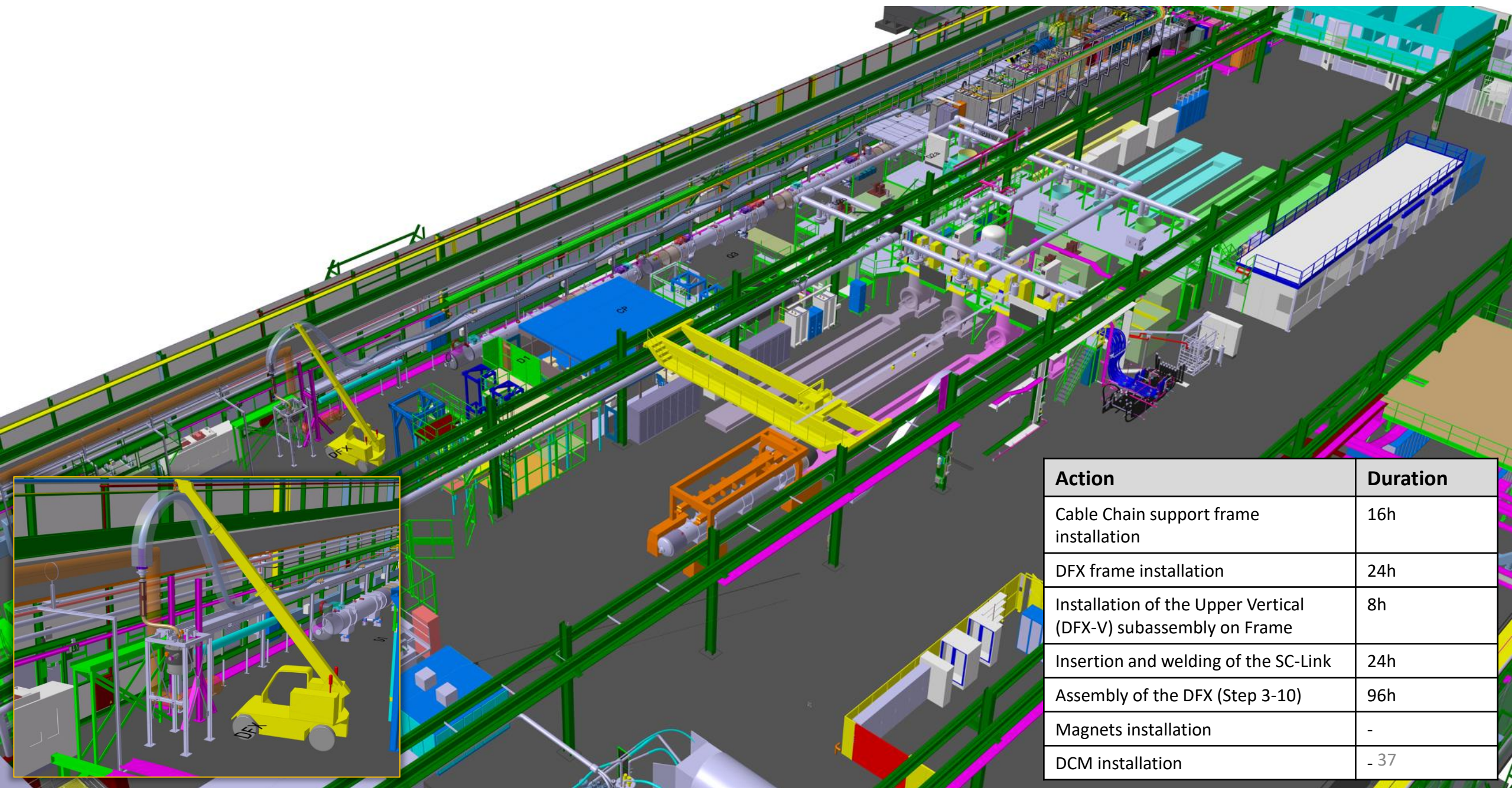
# Phase 3: DFX assembly and NbTi extremity installation



Action	Duration
Cable Chain support frame installation	16h
DFX frame installation	24h
Installation of the Upper Vertical (DFX-V) subassembly on Frame	8h
Insertion and welding of the SC-Link	24h
Assembly of the DFX (Step 3-10)	96h
Magnets installation	-
DCM installation	- 36



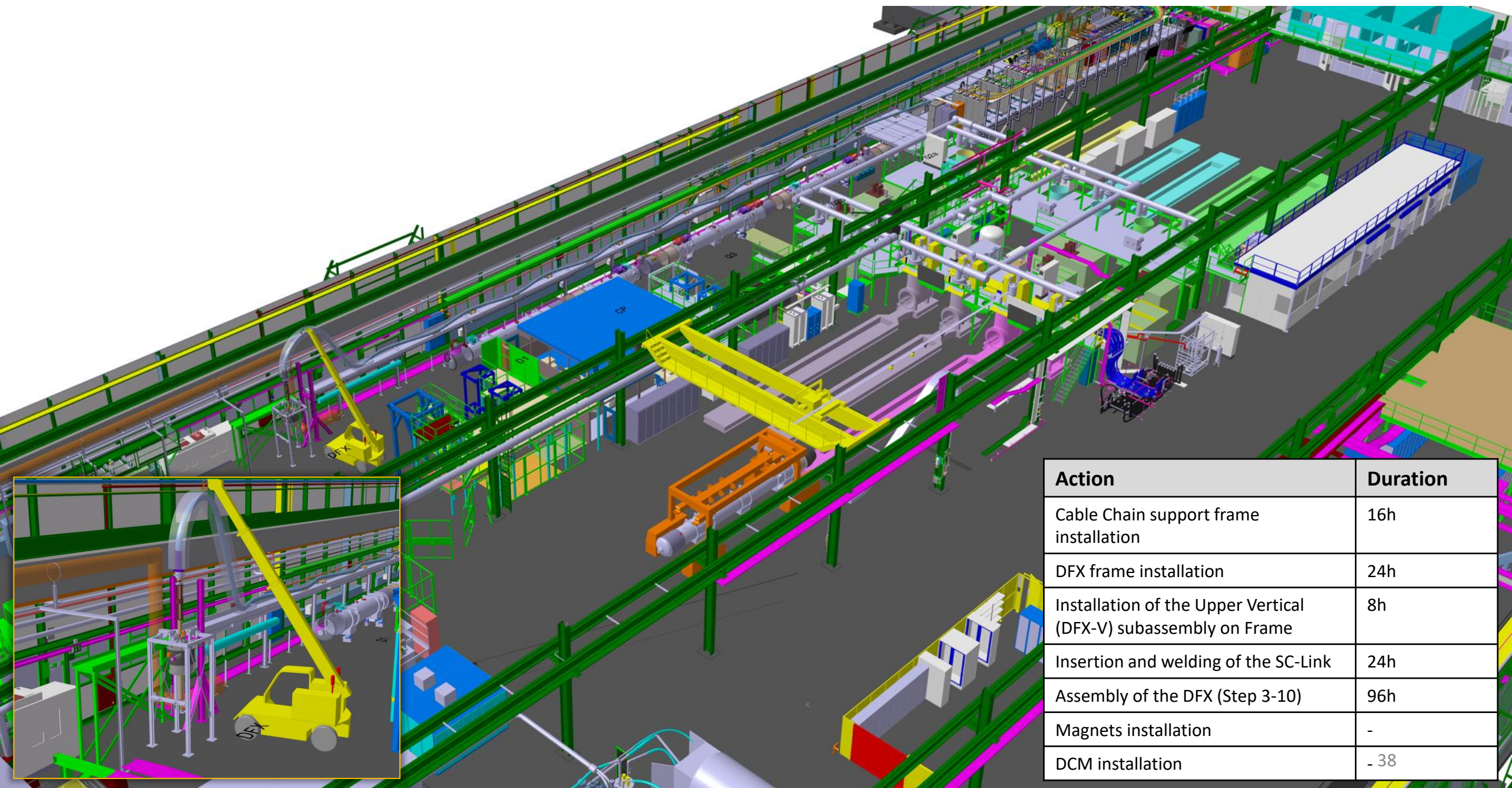
# Phase 3: DFX assembly and NbTi extremity installation



Action	Duration
Cable Chain support frame installation	16h
DFX frame installation	24h
Installation of the Upper Vertical (DFX-V) subassembly on Frame	8h
Insertion and welding of the SC-Link	24h
Assembly of the DFX (Step 3-10)	96h
Magnets installation	-
DCM installation	- 37



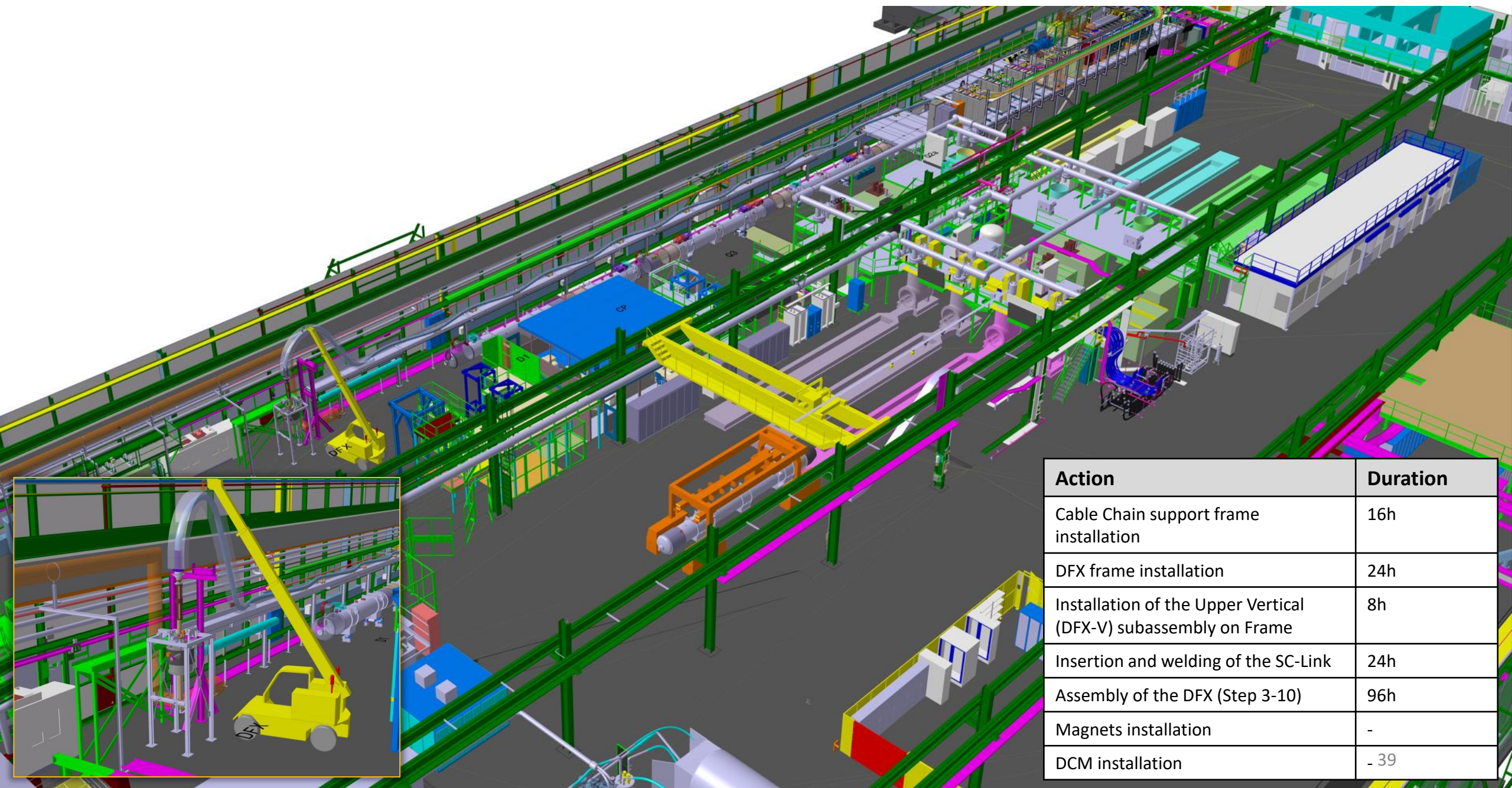
# Phase 3: DFX assembly and NbTi extremity installation



Action	Duration
Cable Chain support frame installation	16h
DFX frame installation	24h
Installation of the Upper Vertical (DFX-V) subassembly on Frame	8h
Insertion and welding of the SC-Link	24h
Assembly of the DFX (Step 3-10)	96h
Magnets installation	-
DCM installation	- 38



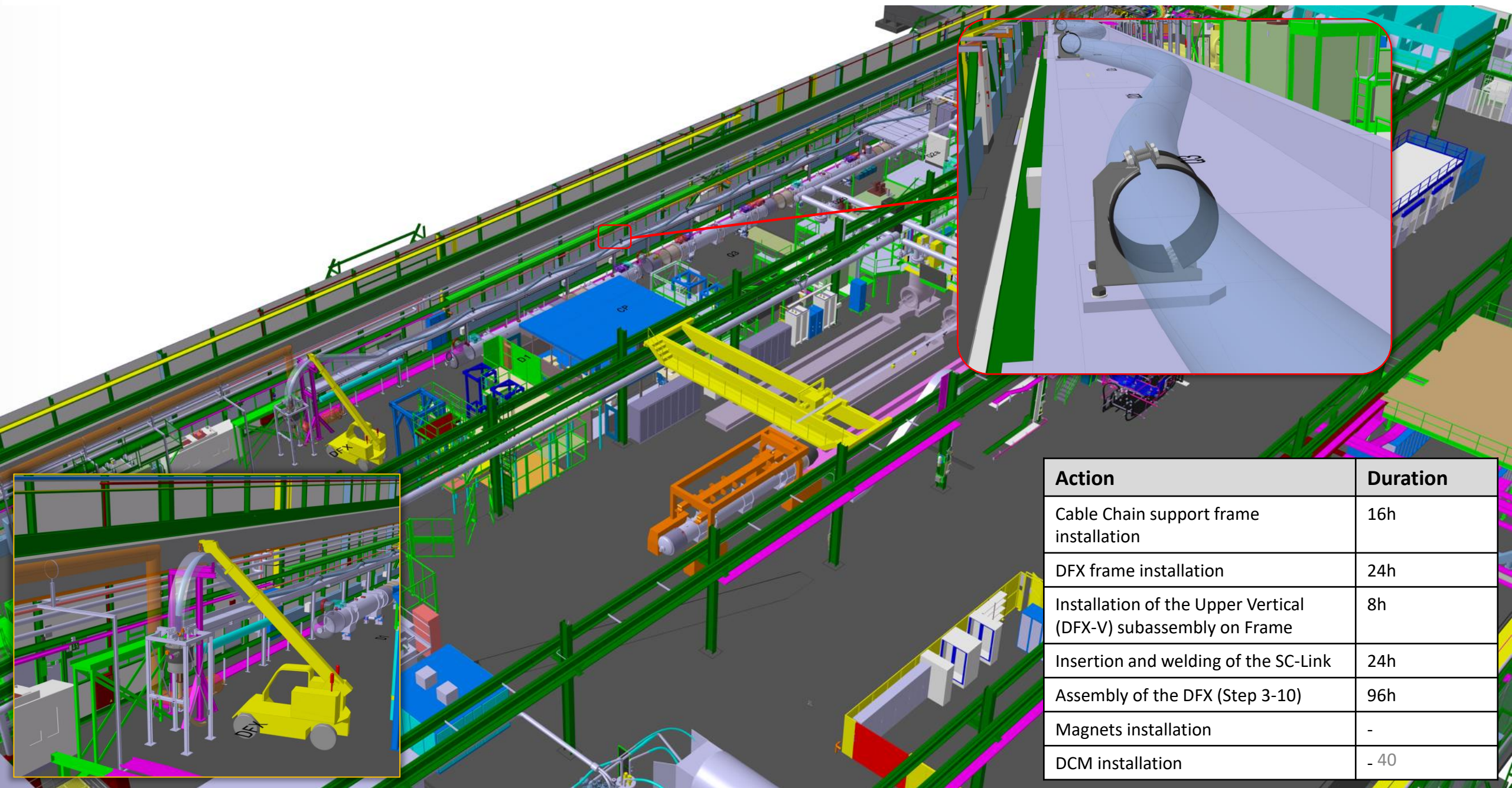
# Phase 3: DFX assembly and NbTi extremity installation



Action	Duration
Cable Chain support frame installation	16h
DFX frame installation	24h
Installation of the Upper Vertical (DFX-V) subassembly on Frame	8h
Insertion and welding of the SC-Link	24h
Assembly of the DFX (Step 3-10)	96h
Magnets installation	-
DCM installation	- 39



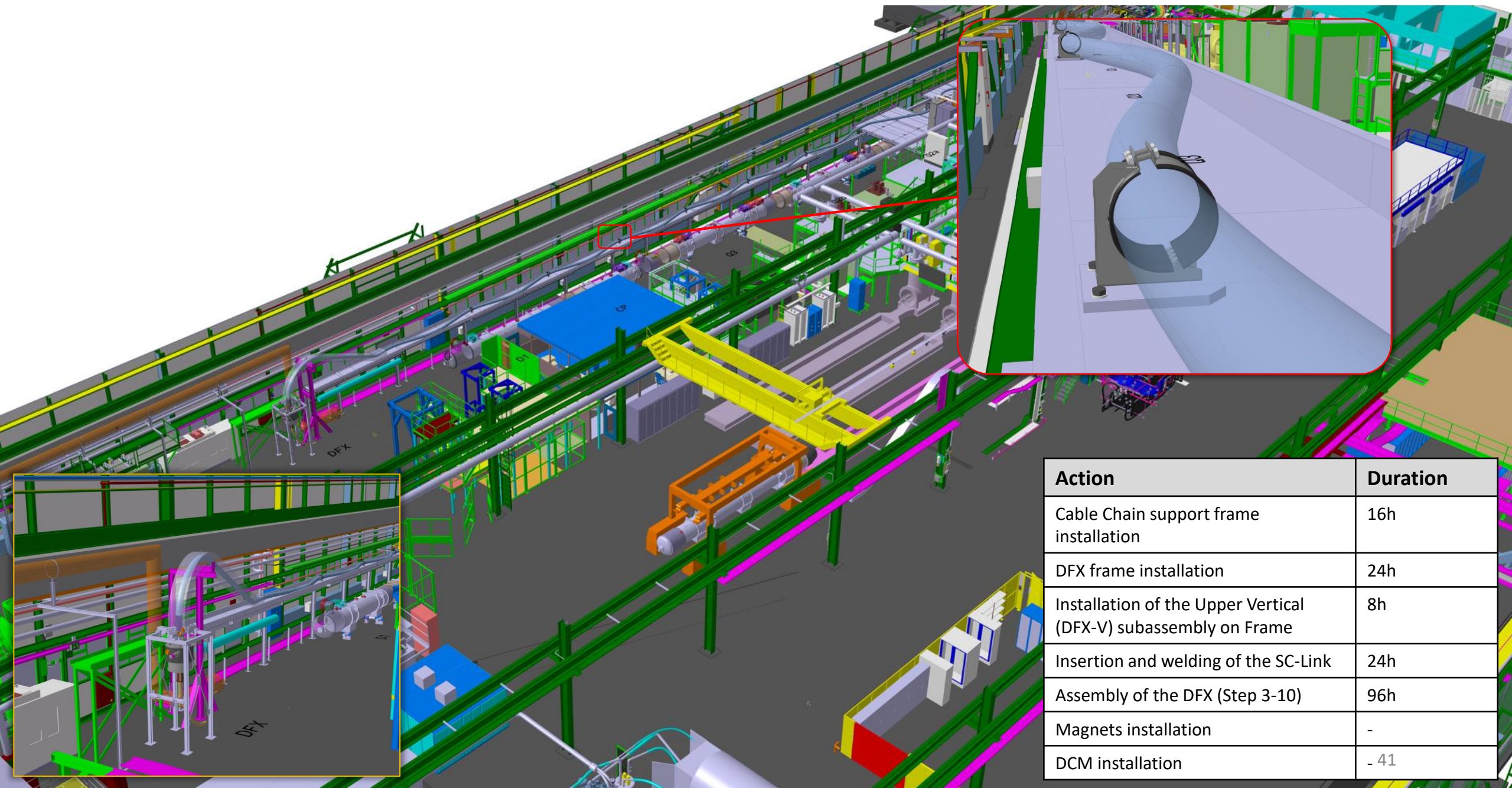
# Phase 3: DFX assembly and NbTi extremity installation



Action	Duration
Cable Chain support frame installation	16h
DFX frame installation	24h
Installation of the Upper Vertical (DFX-V) subassembly on Frame	8h
Insertion and welding of the SC-Link	24h
Assembly of the DFX (Step 3-10)	96h
Magnets installation	-
DCM installation	- 40



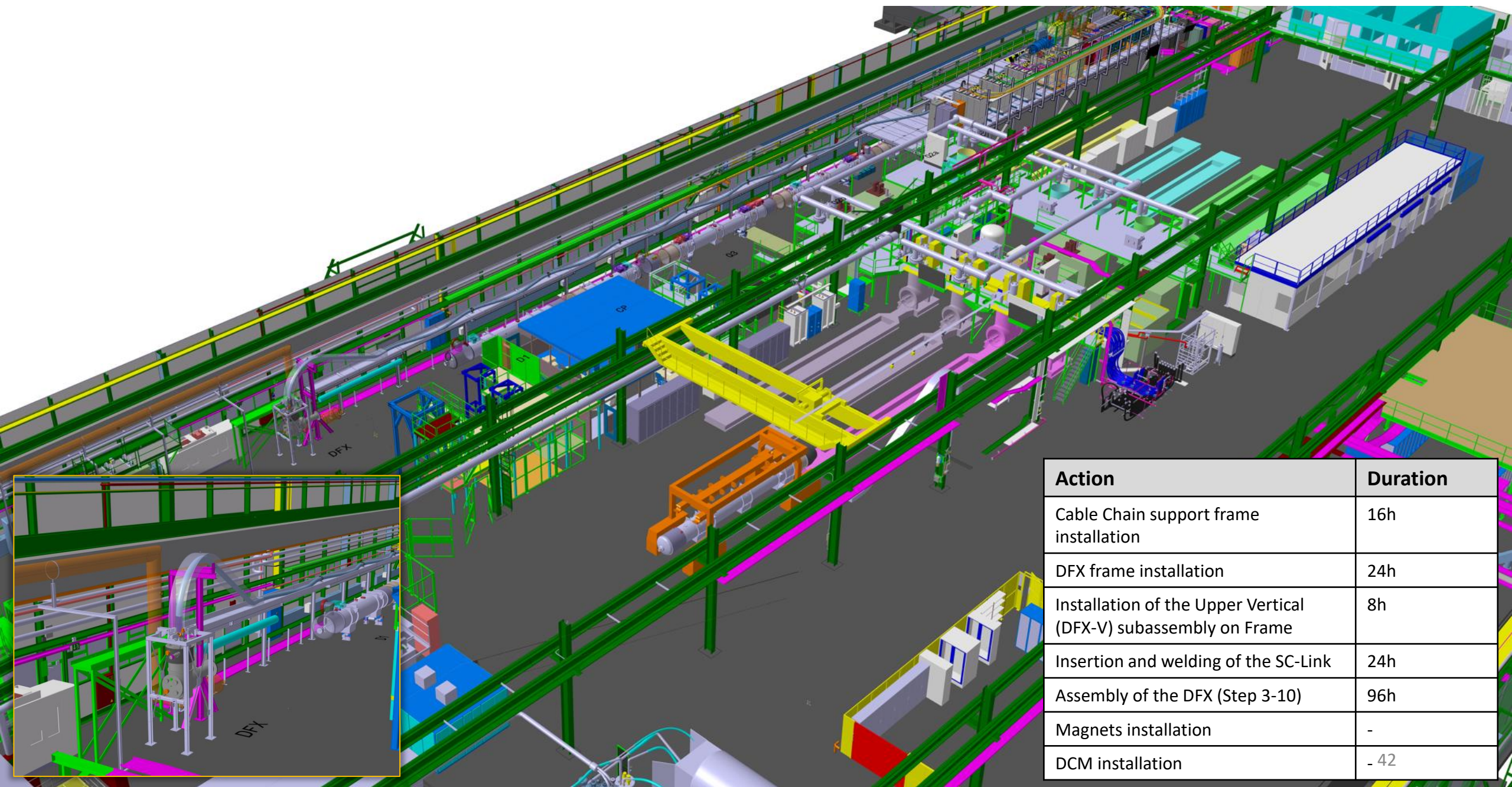
# Phase 3: DFX assembly and NbTi extremity installation



Action	Duration
Cable Chain support frame installation	16h
DFX frame installation	24h
Installation of the Upper Vertical (DFX-V) subassembly on Frame	8h
Insertion and welding of the SC-Link	24h
Assembly of the DFX (Step 3-10)	96h
Magnets installation	-
DCM installation	- 41

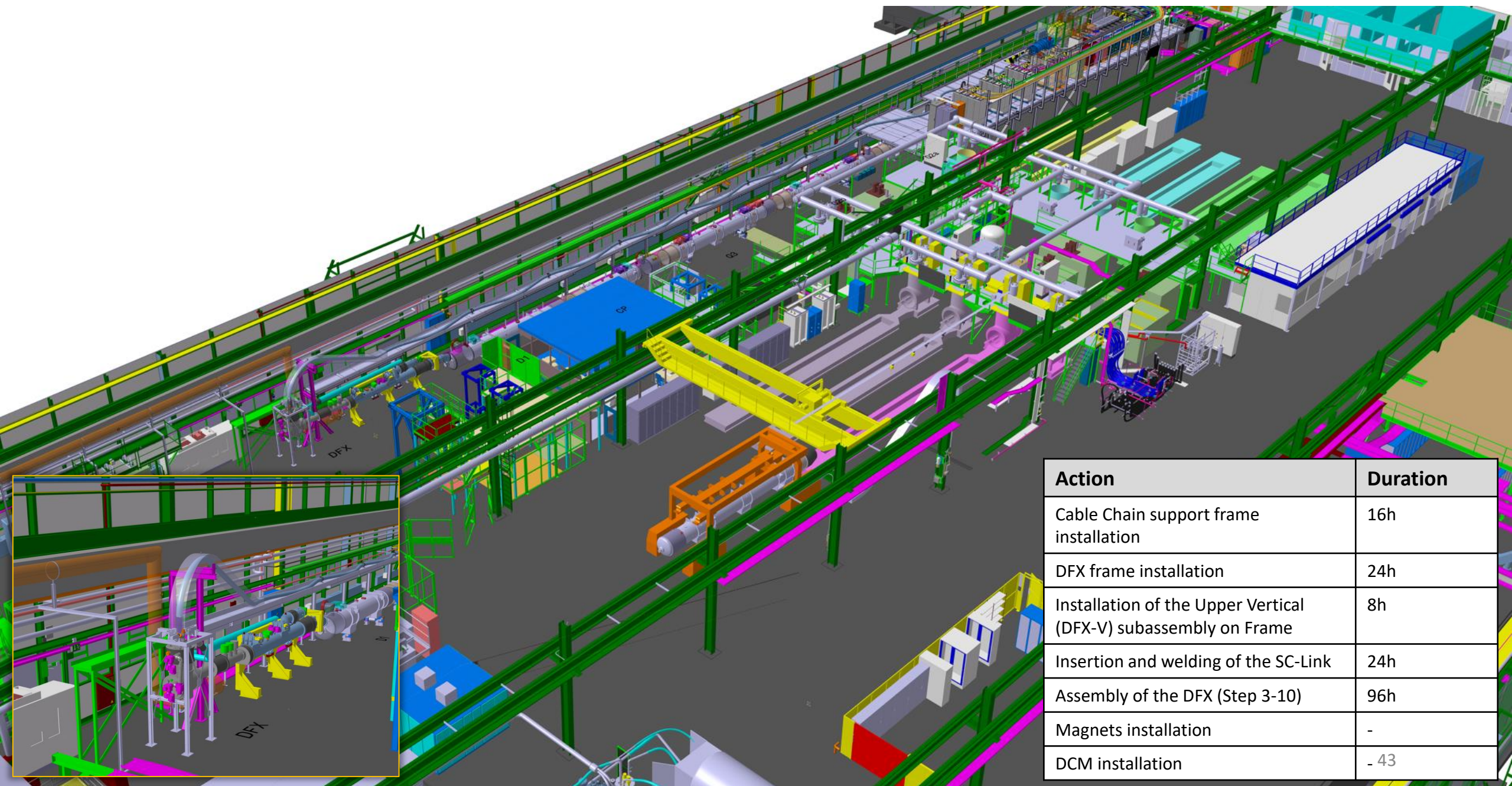


# Phase 3: DFX assembly and NbTi extremity installation





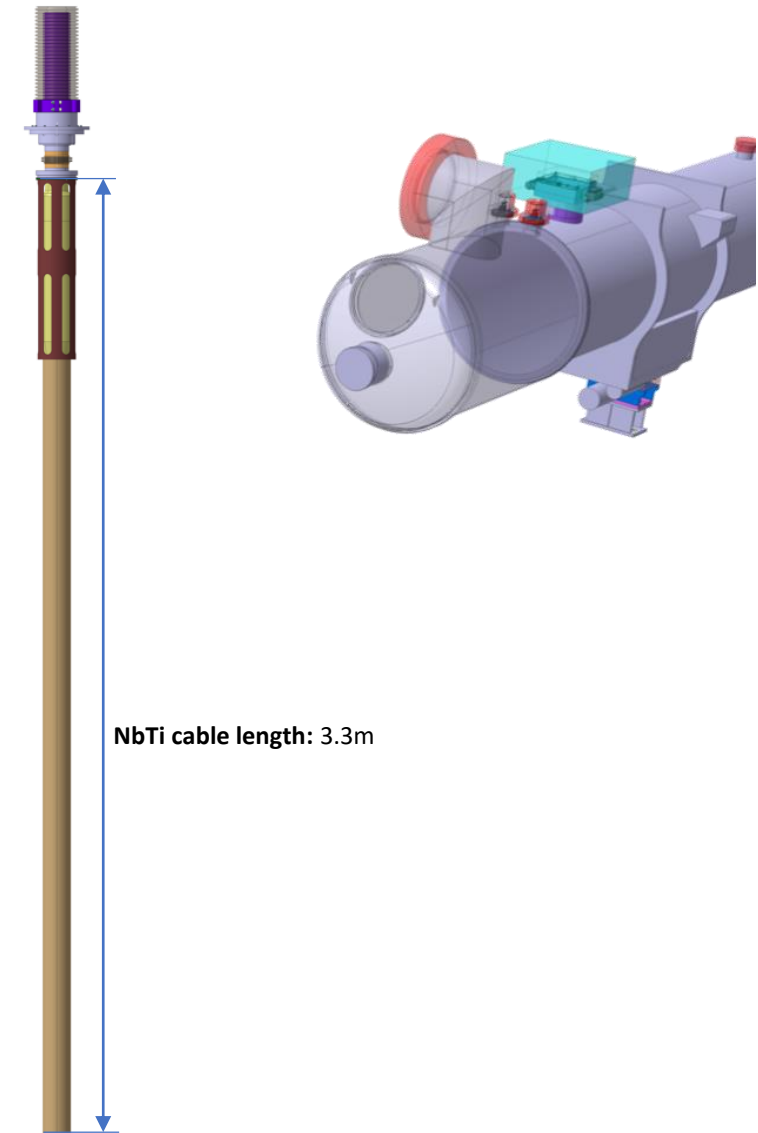
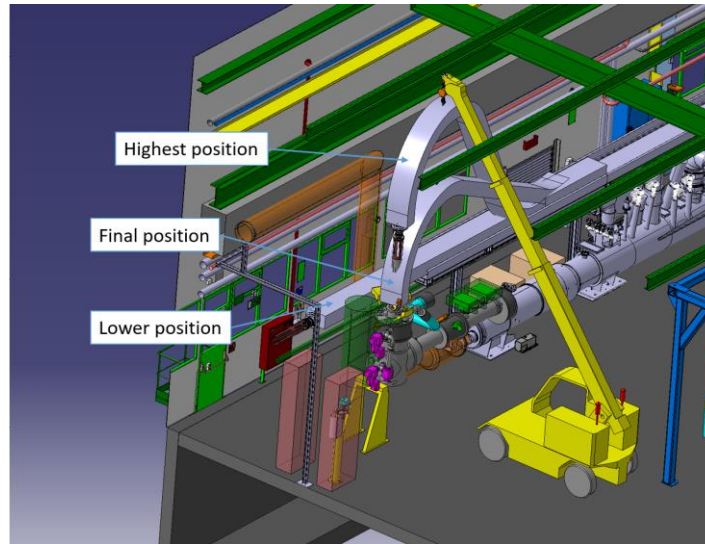
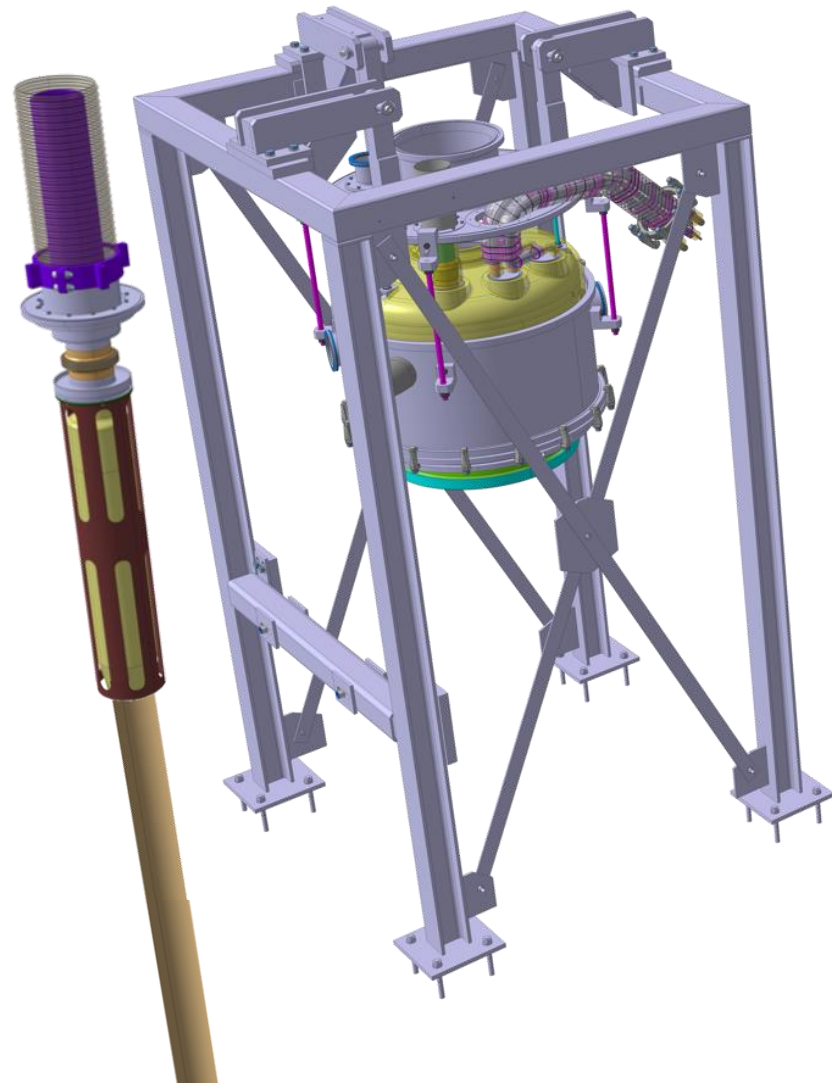
# Phase 3: DFX assembly and NbTi extremity installation



Action	Duration
Cable Chain support frame installation	16h
DFX frame installation	24h
Installation of the Upper Vertical (DFX-V) subassembly on Frame	8h
Insertion and welding of the SC-Link	24h
Assembly of the DFX (Step 3-10)	96h
Magnets installation	-
DCM installation	- 43

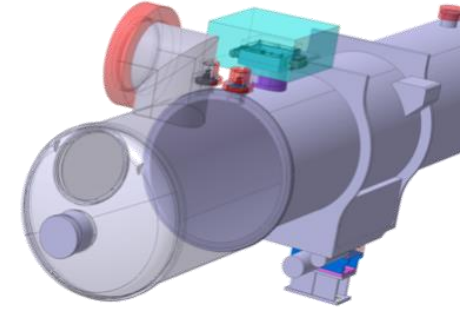
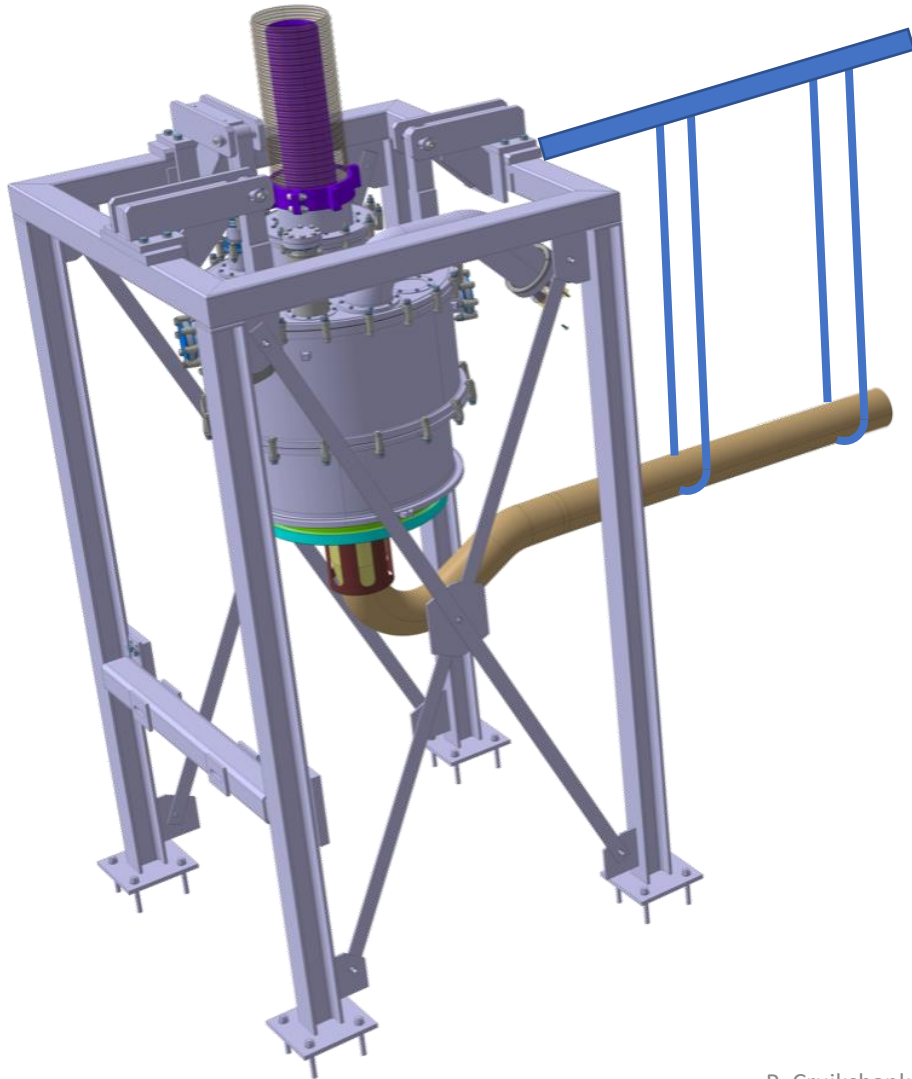


## 2.3 Insert SC-Link into the dome through the VV Hat



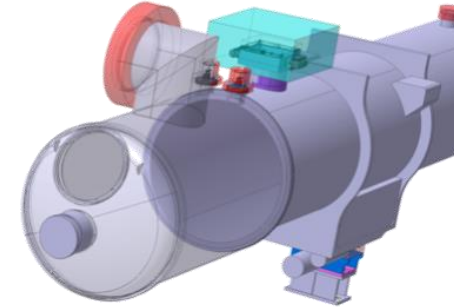
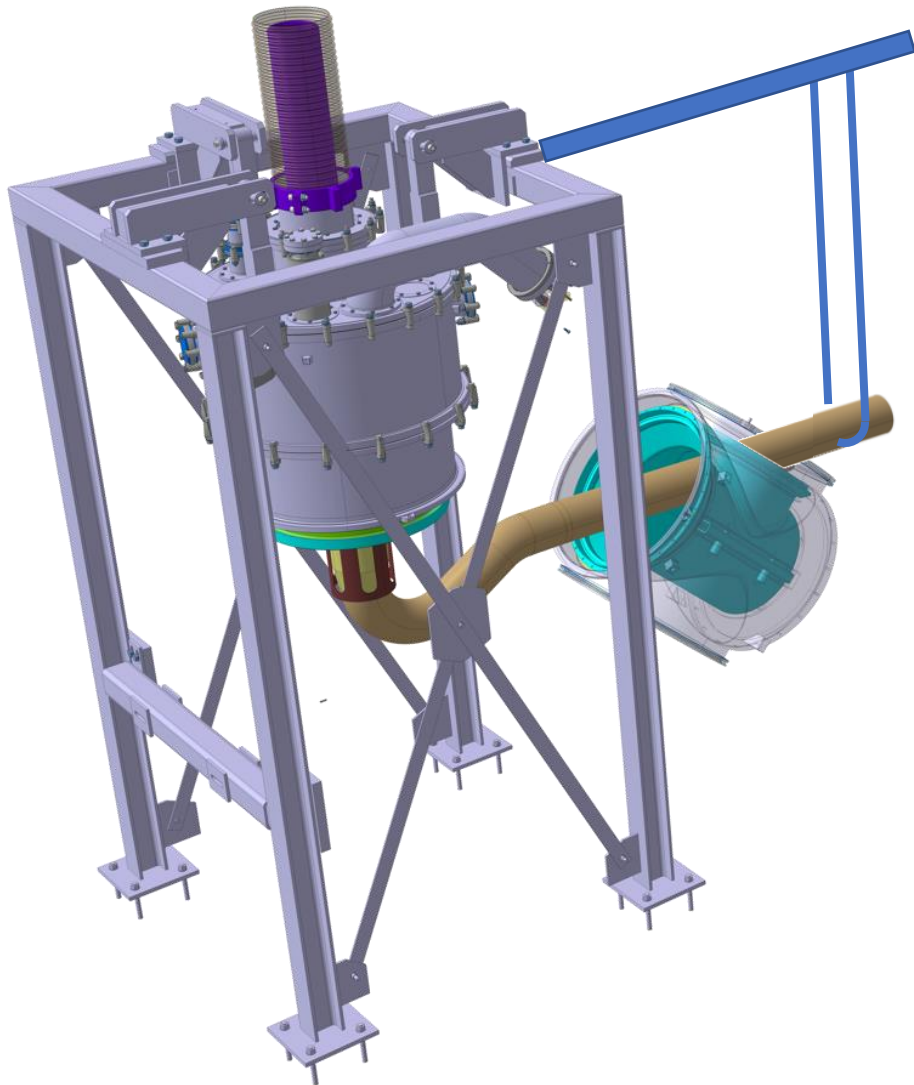


## 5. Insertion of DFX-V | Low





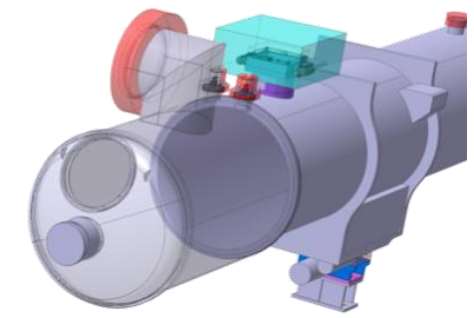
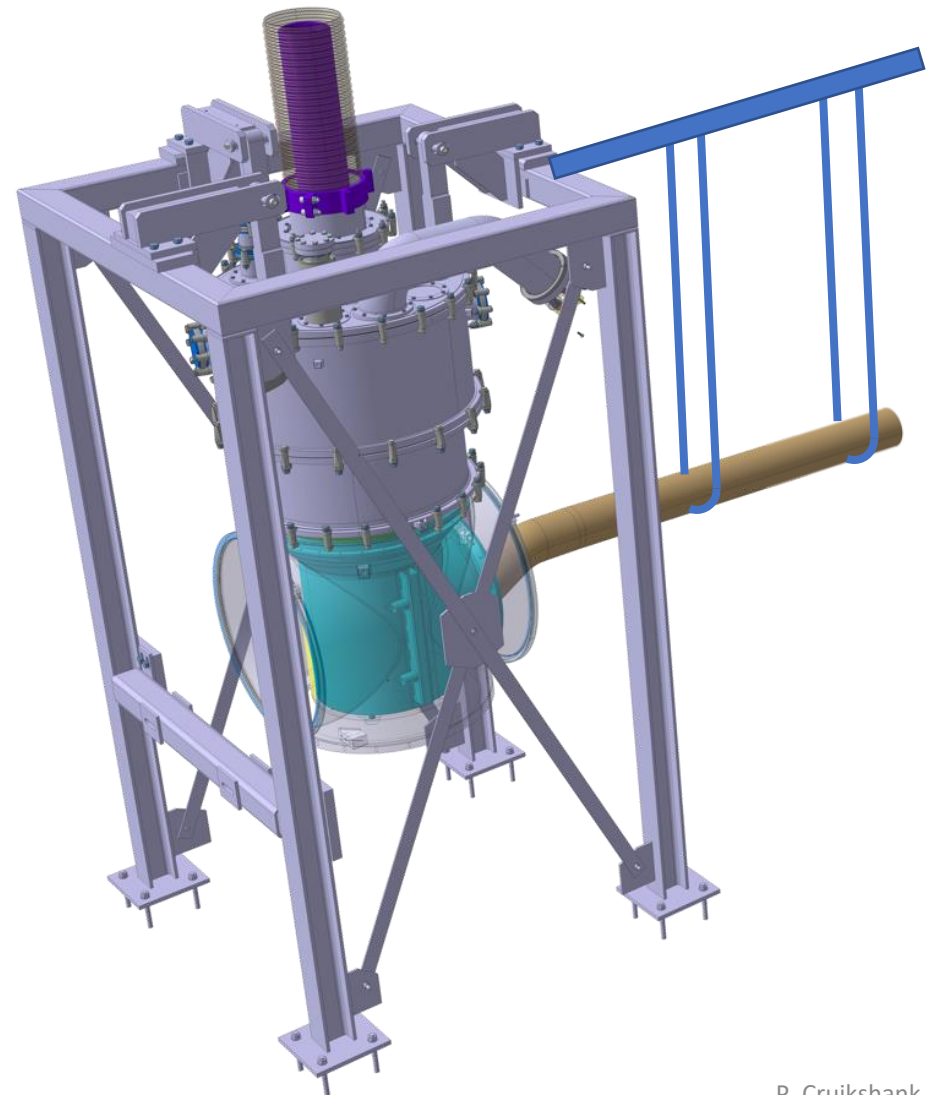
- 5.1 Lift and position the DFX-V | Low subassembly
- 5.2 Insert carefully without damaging the SC-Link.





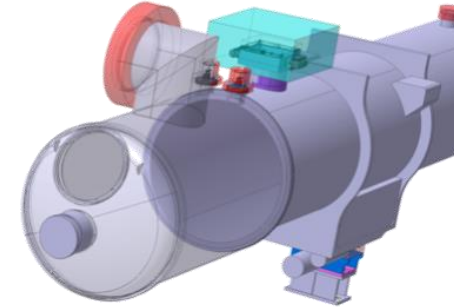
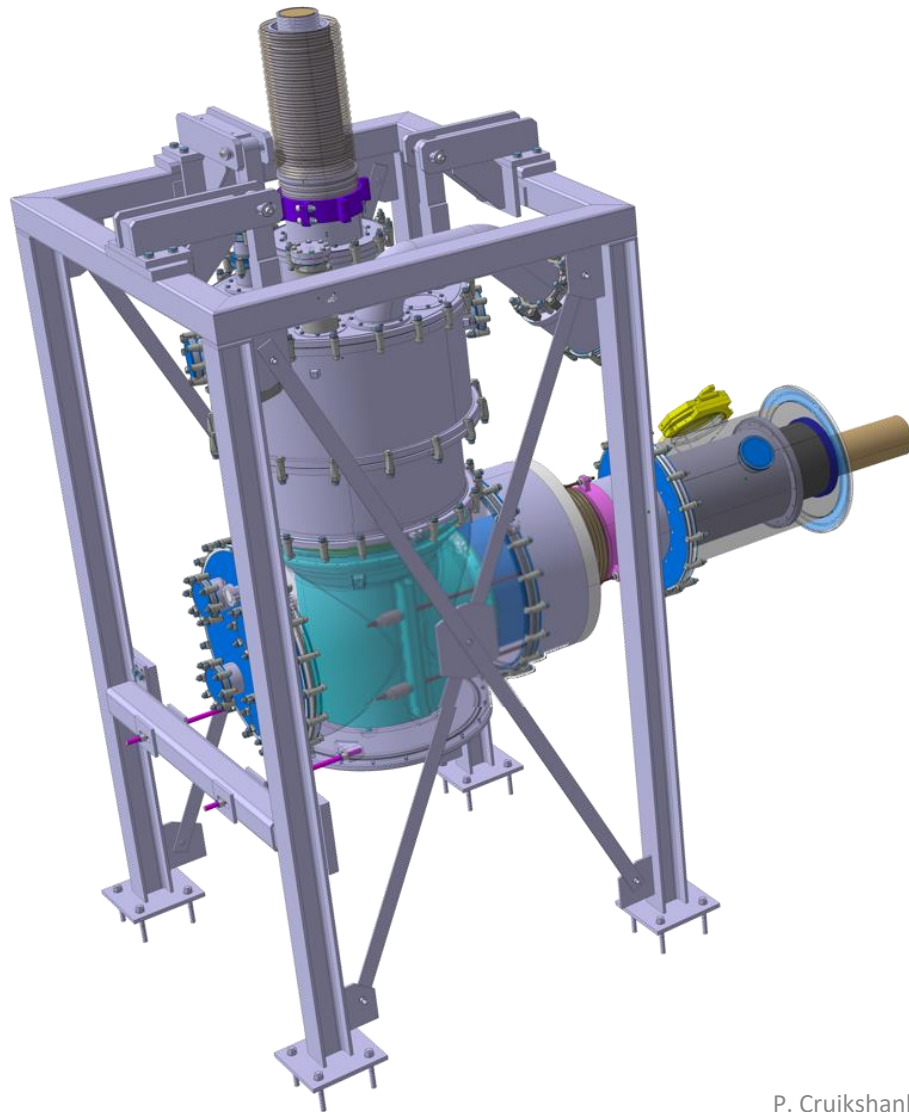
5.10 Lift the VV of the elbow

5.11 Clamp it to the DFX-V subassembly





## 6.15 Position and slide the VV+HV Sleeves towards the DFX-V elbow

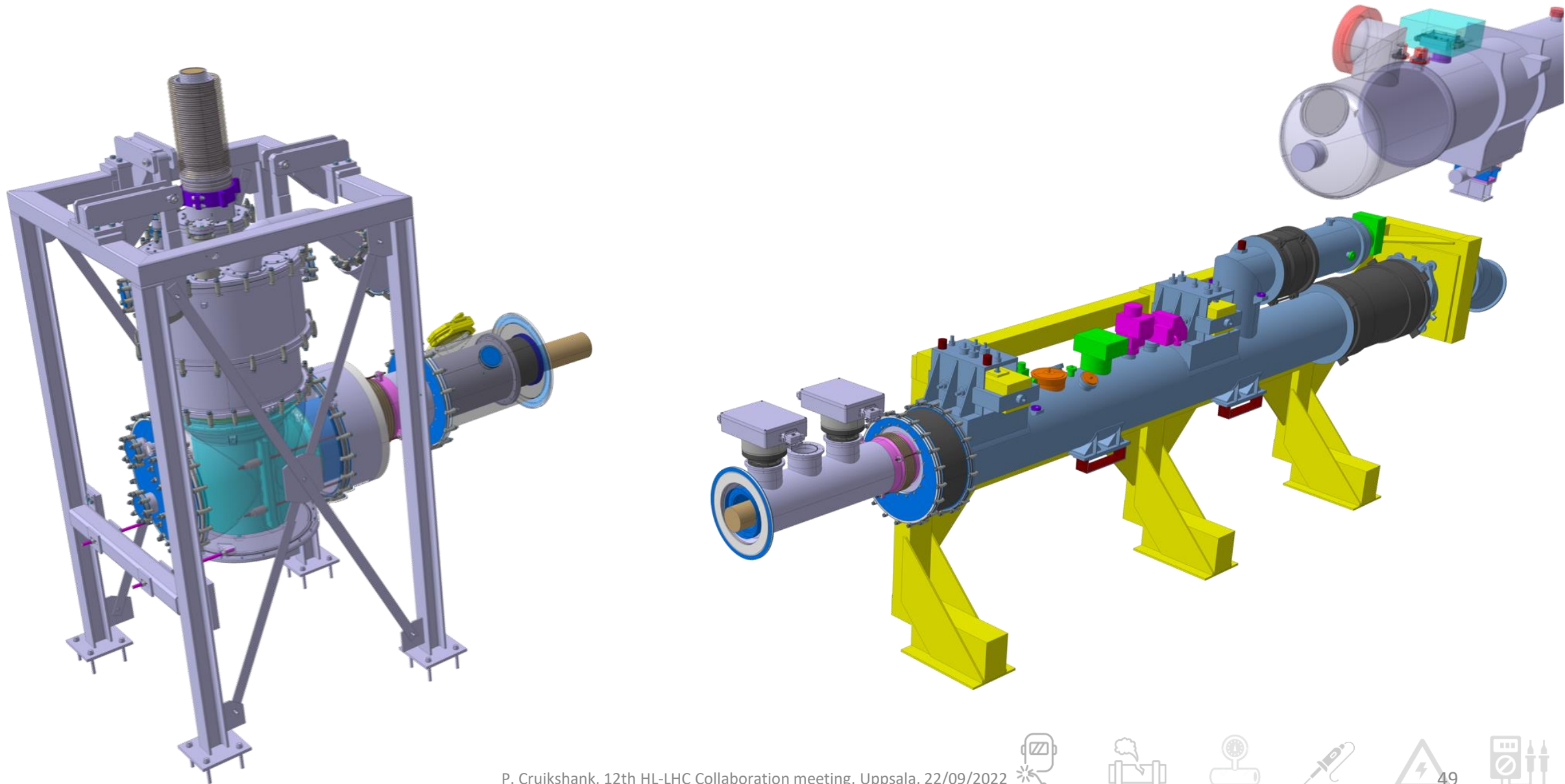


While awaiting installation of DCM, the interconnect will be temporarily closed to protect the cables, helium volume and insulation vacuum volume





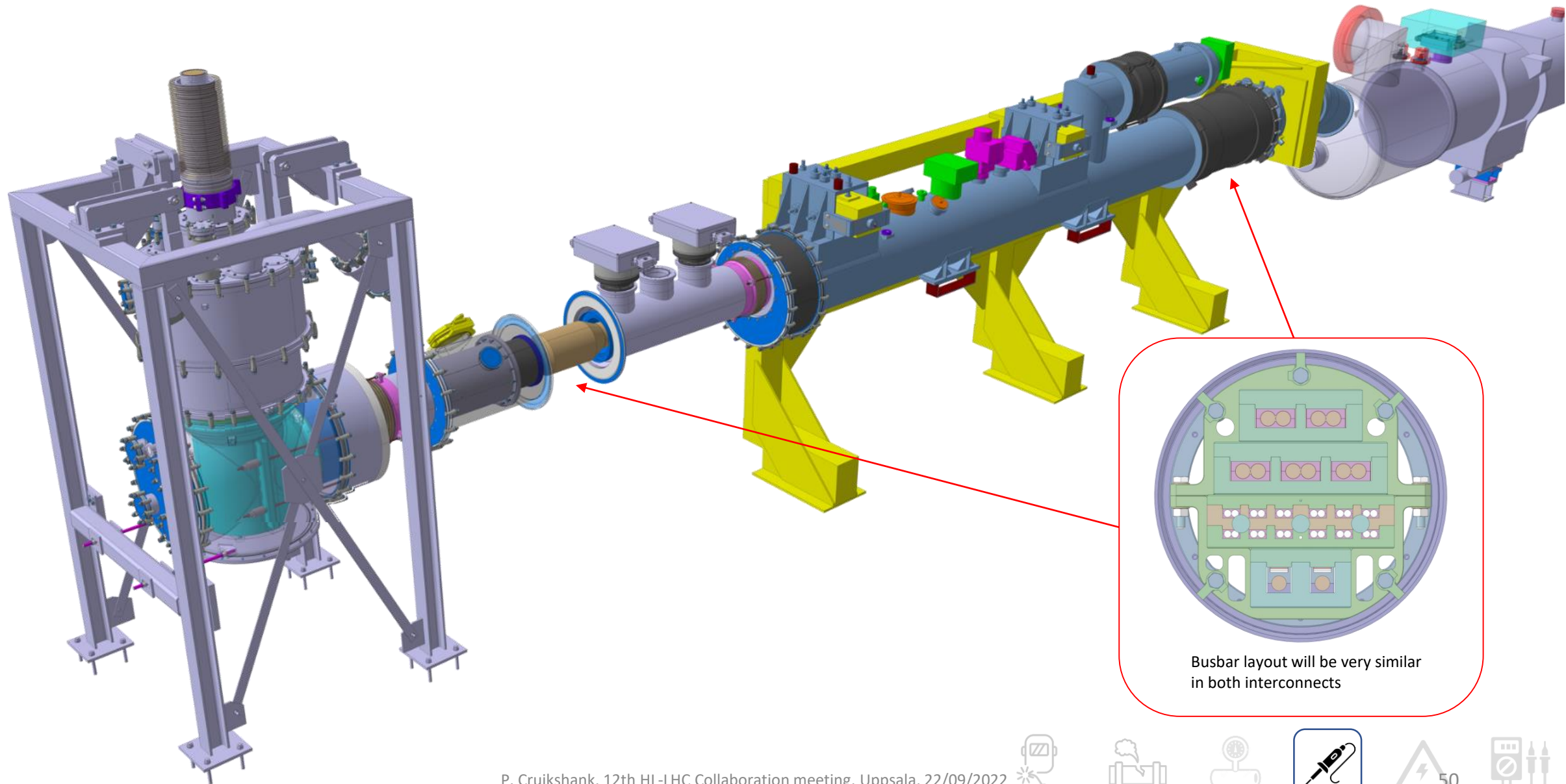
## 7.4 Position the DCM / DFX-h | Plug Side subassembly at the IT string





# 7.5 NbTi-NbTi splices soldering

## 7.6 SCLink - IFS instrumentation joining



Busbar layout will be very similar in both interconnects







4 m spool

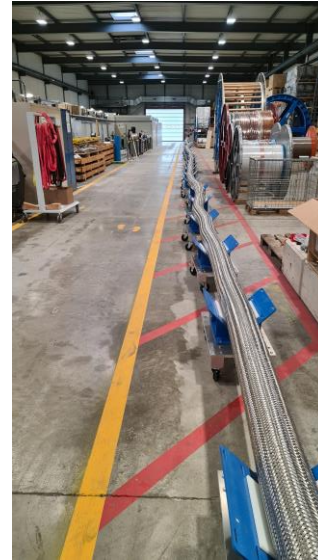
3 m spooler to be upgraded to 4m



# Tooling Readiness

Progress....but, still work to do

WP6a acknowledges the strong support of the EN-HE-PO team

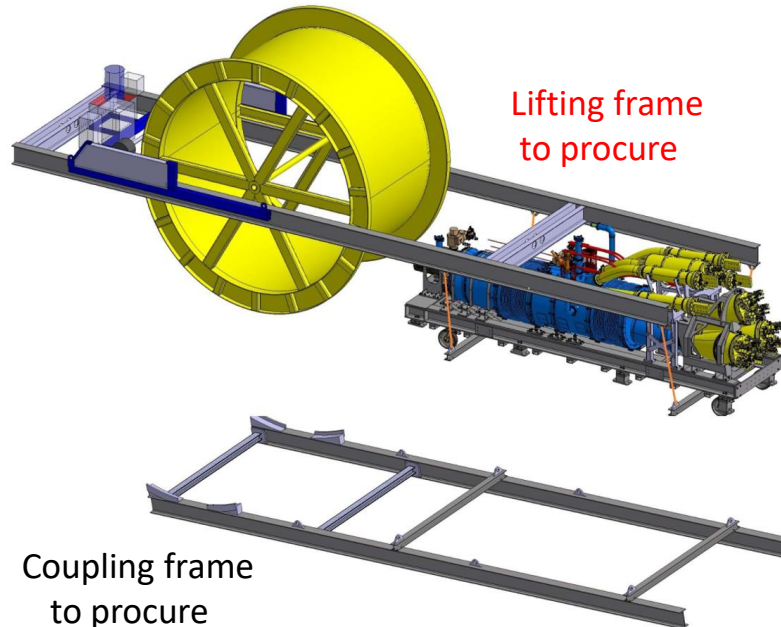


V Trolleys



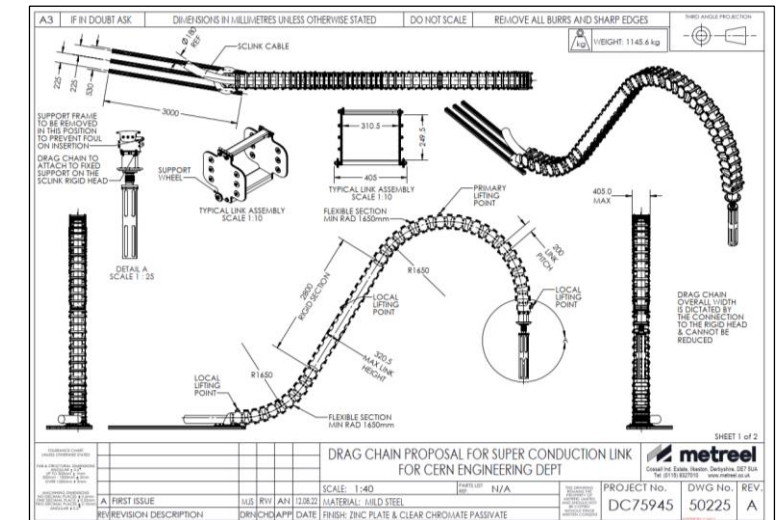
Existing cable chain at F2

IT String Cable chain to procure



Lifting frame to procure

Coupling frame to procure





# Cold Powering Hardware for IT String

- The IT String is assembled from HL-LHC machine equipment/spares which will be recovered later.
- Due to integration differences with respect to the tunnel and other SM18 constraints, [some hardware and tooling for the cold powering system are IT String specific.](#)
- Manpower support to execute the installation, handling, interconnections, welding, quality controls (leak test, pressure test, ELQA, etc) are IT String specific.

Hardware Description	Category
DFHX-DSHX unit	Machine spare
DFHX proximity equipment support	Machine spare
DFHX to platform fixation	String
DFHX to GMS cold piping	String
DFHX to GMS warm piping	String
DFHX to GMS cold piping weld/leak test	String
DFHX vacuum barrier bypass	Machine spare
DFHX splitting box	Machine spare
DFHX Safety valve/burst disc	Machine spare
DFHX IP2X safety cage	Machine
DFHX-DSHX coupling frame	Machine tooling
DFHX-DSHX lifting frame	String tooling
DSHX fixed points	Machine spare
DSHX cable chain	String
DSHX cable chain fixed support	String
DSHX temporary platform for cable chain	String tooling
DSHX consolidation of support tray	String
DFX unit	Machine spare
DFX support frame	String
DFX to SXML cold piping	Machine
DFX to SXML cold piping weld/leak test	String
DFX interconnection parts (NbTi-NbTi)	String
DFX vacuum barrier bypass	Machine spare
DFX safety valve/burst disc	Machine spare



# TE-MSc Resources (for WP6a) at IT String

- To determine TE-MSc manpower requirements of the installation of the cold powering system at the IT String, the following assumptions/agreements are made with respect to supporting teams:
  - Installation coordination & planning: WP16
  - Installation handling in SM18\*: EN-HE contribution in SM18 (up to 2 persons)
  - Supports & their installation: WP6a team open jobs with EN-ACE
  - DFX assembly work: WP6a team contribution.
  - Cold powering subsystem welding\*\*:
  - DFX interconnection & welding (NbTi): TE-MSc contribution (magnet interconnection team\*\*\*)
  - Vac instrumentation & pumping: TE-VSC contribution
  - Interconnect & global leak tests: TE-VSC contribution
  - ELQA & electrical protection: TE-MPE contribution
  - Metrology: WP6a team open jobs with BE-GM
  - Instrumentation cables/boxes DFHX & DFX: WP6a & WP7 teams

\*all Sc link handling is done in collaboration with WP6a team

\*\*welding needs: DFX assembly including off-line joining to DCM; DFX-SQXL transfer line; DFHX-GMS transfer line

\*\*\* welding strategy agreed 31/08/2022 with TE-MSc hierarchy.







# TE-MSc Resources (for WP6a) at IT String

- Documents prepared by WP6a & WP16 to collate IT String interfaces, activities & resources:
  - Interface Specification of WP6a in IT String – edms 2087862 (95% complete)
  - TE-MSc Contribution (for WP6a) to WP16 – edms 2188577 (95% complete)
  - DFX assembly sequence @ IT String – <https://cernbox.cern.ch/index.php/s/q02aVBvLn6l8Ufp>
  - Cold Powering assembly sequence @ IT String – <https://cernbox.cern.ch/index.php/s/DzSmU6aVmdzpkQk>
- IT String installation will profit from experience gained during Cold Powering proto system test at F2 (plus prior DEMO trials)

- TE-MSc (for WP6a) resources @ IT String
  - Staff Project Engineer
  - Staff Technician
  - FSU Technician
  - TE-MSc synergies (eg field coordinator/QA/QC)
  - Hardware + M4P = 330 kCHF

Table 5: FTE of Staff per year

Group	2021 study	2022 preparation	2023 installation	2024-2025 commissioning & operation	2026 dismantling	Total (FTE·years)
TE-MSc WP6a -Eng	0.05	0.1	0.35	0.2		1.9
TE-MSc WP6a - Tech		0.1	0.7	0.4		

Table 6: FTE of M4P per year

Group	2021 study	2022 preparation	2023 installation	2024-2025 commissioning & operation	2026 dismantling	Total (FTE·years)
TE-MSc WP6a - M4P	0	0.1	0.7	0.1		0.9

Extract 'WP6a contribution to IT String', edms 2188577



# Summary

- F2 Cold Powering Readiness
  - Qualification at F2 is major steppingstone towards IT String – first assembly & test of a HL-LHC cold powering system
  - Consolidated system assembly & test plan gives availability for IT String July 2023
- IT String Cold Powering Readiness
  - Principal equipment is machine spares coming via F2
  - Due to SM18 configuration some IT String specific equipment is being procured.
- Tooling
  - IT string presents a unique challenge to install the 74.5 m system on the platform – lifting tool to be procured.
  - A cable chain at DFX, already validated for the F2 bench, will also be applied for the IT String - to be procured.
- Resources
  - Interface & Contribution documents are now mature, providing activity durations for centralised WP16 planning.
  - IT String specific hardware & manpower needs are identified.
- Installation Sequence
  - WP6a has produced detailed installation sequences - both overall for the system & specific around DFX
  - The sequences allow WP6a to refine detailed steps and communicate our vision to the other teams
- No showstoppers....
  - .....but we don't underestimate the hard work that is still in front of us.



# Thanks for your attention !

WP6a acknowledges the support of all CERN teams and Collaborations working on the HL-LHC, IT String and F2 cold powering configurations.



# Spare Slides



# WP7/MPE contribution for cold powering



EDMS NO. 2779589	REV. 0.1	VALIDITY DRAFT
REFERENCE: NOT REQUIRED		

## HL-LHC IT String Meeting Minutes

### WP7/MPE contribution to WP16 for the cold powering system

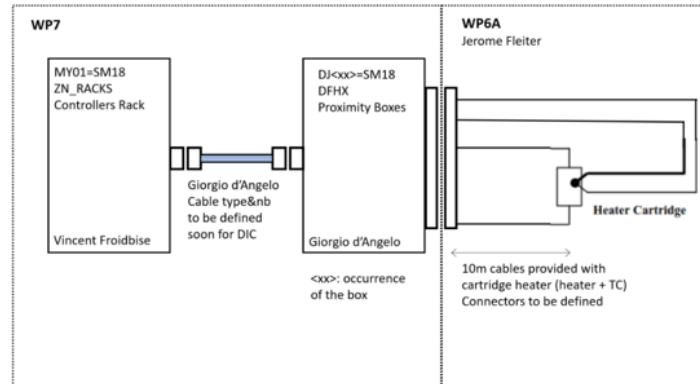
Date: 2022-09-13

Project/Activity: WP16

Attendees: Marta Bajko (MB), A. Ballarino (AB), Nicolas Heredia Garcia (NH), Felix Rodriguez Mateos (FR), D. Wollmann (DW) and Samer Yammine (SY).

### DISCUSSION

#### DFHX – Current Lead heaters

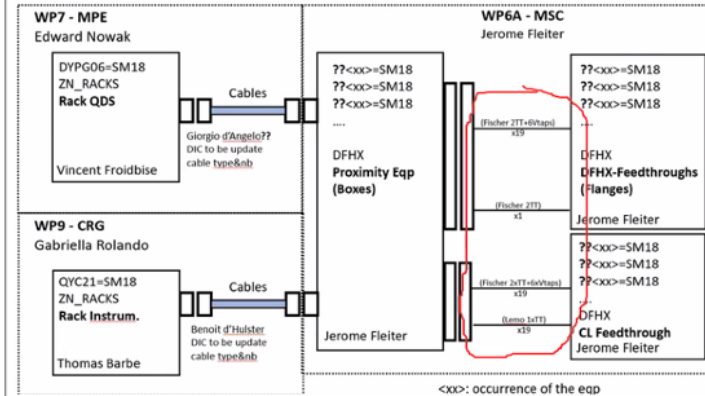


- Heater cartridge delivery (including 10 m cables): WP6A
- Integration of proximity boxes (including drawings, supports): WP6A
- Proximity boxes delivery (including transformers): WP7
- Controller rack (including electronics): WP7
- Cabling from controllers rack to proximity boxes: WP16 (inside WP6A WU, E. Nowak as reporting person) (Current budget allocation: 10 kCHF)



EDMS NO. 2779589	REV. 0.1	VALIDITY DRAFT
REFERENCE: NOT REQUIRED		

#### DFHX – Splitting modules



- Splitting box (including hardware inside) delivery: WP6A
- Integration of proximity boxes (including drawings, supports): WP6A
- QDS rack (including electronics): WP7
- Cabling from QDS rack to proximity boxes: WP16 (inside Machine Protection WU)

#### DFX – IFS boxes

