WP16: IT STRING & COMMISSIONING

SUMMARY OF TE-MSC (WP6A) CONTRIBUTION TO WP16

Abstract

This document summarises the involvement of Work Package 6A of HL-LHC (Cold Powering) in the Inner Triplet String.

It describes the scope, schedule, cost, resources and the related documentation. Any changes in cost and/or schedule are presented in the reports prepared for Project Steering Meetings that are referred to in this document and integrated here after each Cost and Schedule Review.

The cost of the contribution of WP6A (Cold Powering) to the IT String is within the CtC of WP16.

TRACEABILITY

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Distribution: All TE-MPE-SF members, M. Zerlauth	

Rev. No.	***Date***	***Description of Changes*** *(major changes only, minor changes in EDMS)*
0.1	2021-02-23	First issue.
0.2	2022-05-24	Revision and update
0.3	2022-07-14	Updated introduction, moved interfaces to 207862 and minor modifications. Added resources and table of activities
		P. Cruikshank comments & additions 26/08/2022
		Comments by Amalia 30 August

TABLE OF CONTENTS

1 DEFINITION AND STAKEHOLDERS OF THE CONTRIBUTION DOCUMENT

This document is a joint effort between WP16 and WP6A to describe the contribution of WP6A within the framework of the HL-LHC IT String. It will serve as a written agreement between the parties. As such, should be observed during the lifetime of the HL-LHC IT String. Any change shall be discussed among the stakeholders and implemented in a new version of the document.

In the following table can be observed the main roles involved in the HL-LHC IT String and particularly in this contribution:

Role	Person	Dep. – Group - Section	Responsibility
WP16 Leaders	M. Bajko	TE-MPE-SF	HL-LHC IT String, Budget, Resources and Schedule
	M. Pojer	TE-MPE-MP	HL-LHC Hardware Commissioning
WP16 Members	S. Yammine	TE-MPE-SF	Validation Test Plan
	D. Bozzini	TE-MPE-SF	Safety
	S. Blanchard	TE-MPE-SF	Installation
	J. Zawilinski	TE-MPE-SF	Link to quality tools
	N. Heredia Garcia	TE-MPE-SF	Scientific secretary
	A. Kosmicki	EN-ACE-INT	Integration Designer
	E. Vergara	EN-ACE-OSS	Schedule
WP6A Leaders	A. Ballarino	TE-MSC-SCD	WP6A Leader
	P. Cruikshank	TE-VSC-GLO	WP6A Deputy Leader
WP6A Members	J. Fleiter	TE-MSC-SCD	Cold Powering System Installation and operation
	A. Gharib	TE-MSC-SCD	WP6a Auxiliary Electrical Systems
TE-MSC Leader	A. Devred	TE-MSC	Group Leader
TE-MPE Leader	F. Rodriguez Mateos	TE-MPE	Group Leader

2 BASELINE OF WP16

2.1 Description

The WP16 is part of the project High Luminosity LHC and will be responsible of the coordination of the HL–LHC IT String. The so-called HL-LHC IT String will be a test stand to study and validate the collective behaviour of a set of different systems for the project HL-LHC: magnets, magnet protections, cryogenics for magnets and superconducting link, magnet powering, vacuum and interconnections between the magnets and the superconducting link, alignment, etc.

The HL–LHC IT String simulates the IT region on the left side of LHC-P5 in terms of configuration. As so, it should comprise all the magnets of the insertion region with their cold and warm powering and associated systems from Q1 to D1 magnets

The test will have conditions as similar as possible to the operational ones, however, the slope that is present in the tunnel is not imitated for the HL-LHC IT String. It will constitute an integration and system test of the most critical part of the upgrade. The HL-LHC IT String will represent an extremely valuable training of all the groups involved in the coordination and installation activities.

2.2 Scope of works

The general scope of the WP16 is described hereafter:

- Coordination of the HL-LHC IT String integration, installation and test to deliver the expected results respecting time and cost boundaries.
- Coordination of the commissioning of the HL–LHC equipment as part of the accelerator system.
- Funding the material exclusively used for the HL-LHC IT String. The rest of equipment will be recovered by the different groups for its use in the tunnel or as operational spares.

The present scope of WP 16 does not include the de-installation of the IT String, although the baseline today is to de-install the IT String at end of the tests. The integration of this scope, as well as a revision of the de-installation date and its impact on each of the contributors to the Work Package, is under scrutiny.

3 BASELINE OF WP6A FOR WP16

3.1 Introduction to WP06A

Work Package (WP)6a: Cold Powering is in charge of development, construction and installation of the Cold Powrings Systems for the HL-LHC Triplets and Matching Sections[1]. It includes the Cold Powering System that will be installed and operated in the String.

A Cold Powering System consists of a Superconducting (SC) Link connected at one side to a DFHX/M module, with inside the current leads, and at the other side to the DFX/M module, with inside the Nb-Ti bus-bar connected to the cryo-magnets [2].

The electrical circuit of the insertion region can be divided into two main separate circuits:

- Matching Sections circuit: DFHM - SC Link DSHM – DFM
- Inner Triplets circuit: DFHX – SC Link DSHX – DFX

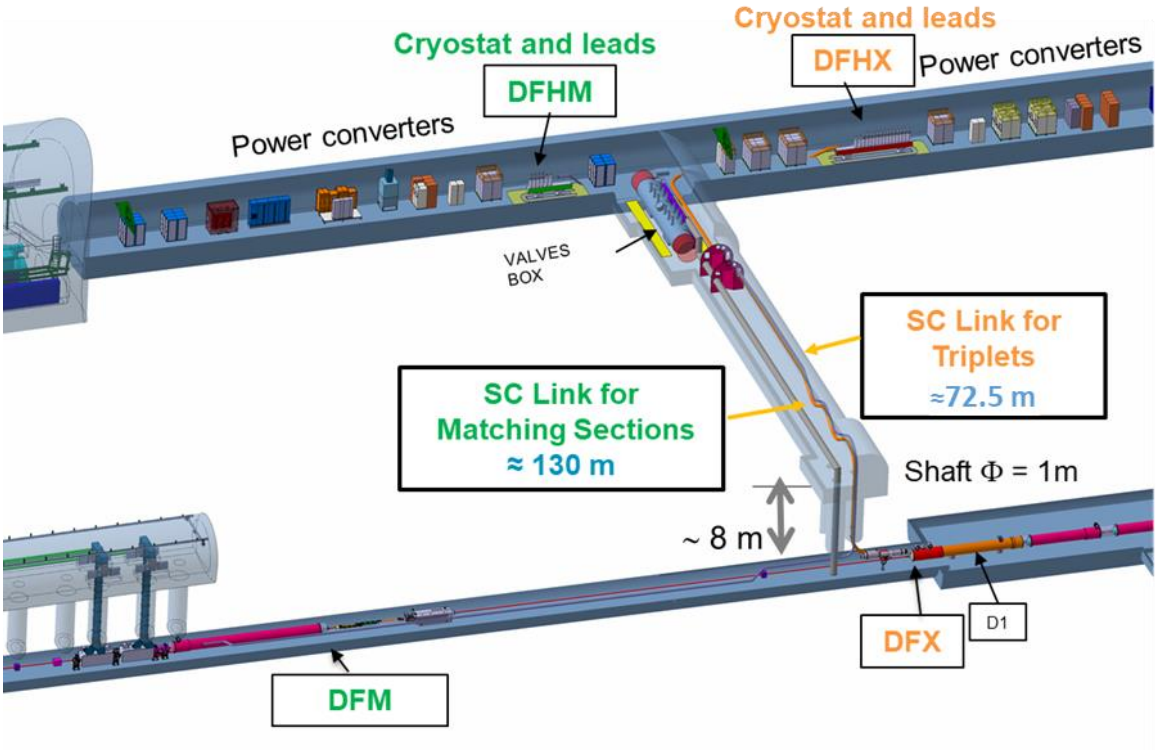

Figure 1: LHC tunnel configuration of the Cold powering system on the Inner Triplet side

The Cold Powering system of the IT String extends from the current leads of the DFHX up to the DFX (included) interfacing with the DCM at the lambda plate. It operates from 4.2 K (LHe) to room temperature. ~~The validation of this system can be extended to the system of the Matching Section side (?).~~

The individual validation of the Cold Powering System is within the scope of WP6A. The IT String allows:

- Validation of Cold Powering System when operated as part of the magnets circuit: in particular, the performance during transients induced by magnets quench and/or induced by a quench in the SC Link, ~~i.e. effect of over-currents in the single circuit with Coupling-Loss Induced Quench (CLIQ) system.~~ Thanks to cold diodes-there is NOT overcurrent in the WP6a circuits
- Validation of performance of lambda-plate, which is part of WP3 and interfaces with WP6a, in final configuration
- Validation of routing and splicing of Nb-Ti bus-bar cables (TE-MSC activity)
- Training of teams performing installation and interconnections in the tunnel (on the DFX and DFHX side)

3.2 Scope of works

WP6A of HL-LHC is responsible of:

- Design, manufacturing and test in nominal operating conditions of the Cold Powering System, mainly composed by DFHX, SC Link, DFX and associated instrumentation.
- Installation of Cold Powering System into the HL-LHC IT String, including the specific tooling for installation and handling.
- Design and installation of electrical auxiliary system, e.g. resistive heaters of current leads
- Proximity equipment at DFX
- Proximity equipment at DFHX

- and associated circuits, interconnection box distributing cryogenic and electrical equipment [xx].

4 CONFIGURATION, HARDWARE AND SERVICES

This section presents the configuration for the layout of the Cold Powering System in the HL-LHC IT String as well as the hardware procured and installed by WP6A in the HL-LHC IT String. Also, the services requested by WP6A to be available in the test stand.

4.1 General configuration layout

Figure2 shows the schematical configuration of the cold powering in the HL-LHC IT String:

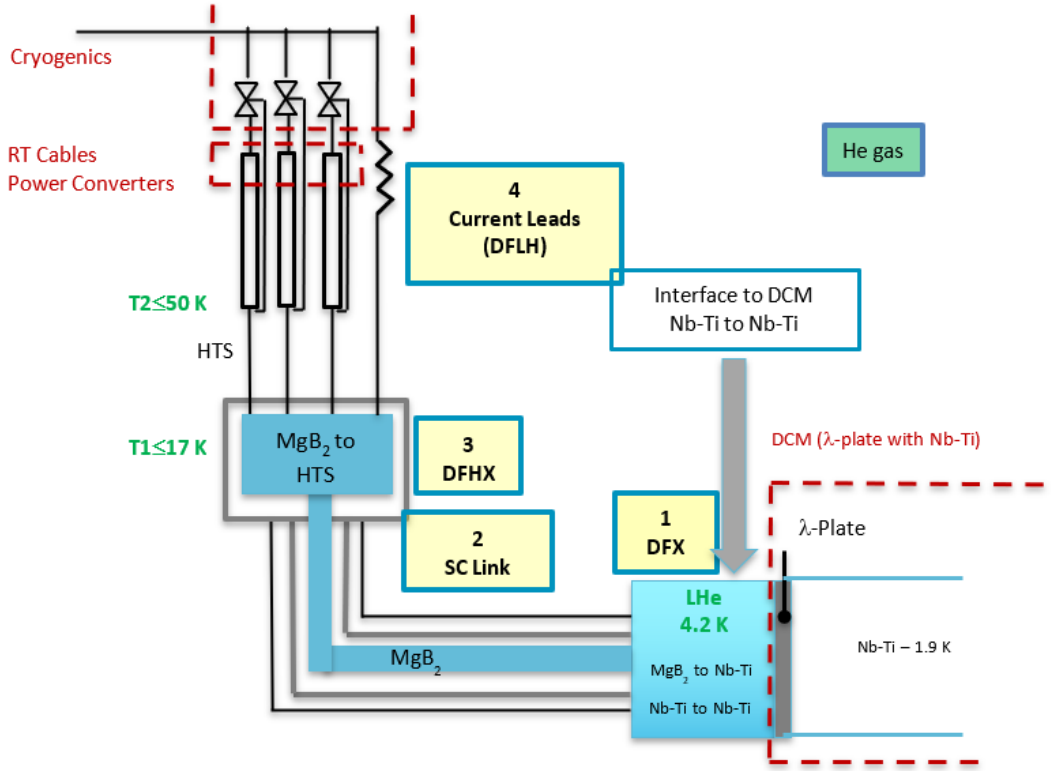

Figure 2: Layout of the Cold Powering system of baseline configuration (ref: A. Ballarino, International Review of HL-LHC Magnets Circuits, 2019 [International Review of HL-LHC Magnet Circuits (9-September 10, 2019): Timetable · Indico (cern.ch)])

4.2 Hardware from WP6A for the IT String

The IT String system, which can be regarded as one of the 4 Cold Powering Systems of the Triplets includes the following main hardware:

- DFX:
    a. Cryostat (pre-series) hosting the MgB_2 to NbTi splices of the SC Link extremity, NbTi-NbTi splices joining the latter to the DCM NbTi cables, IFS feedthroughs – see figure 3
    b. DFX support frame, specific for IT String configuration – 7 kCHF
    c. He transferline SQXL-DFX (to recover for machine)
    d. NbTi-NbTi interconnection parts, specific for IT String assembly – 15 kCHF

e. Welding support from EN-MME during DFX assembly – 10 kCHF

- SC Link:
  a. Cryostat (pre-series) with machine configuration length: 74.5 m long[x] cryostat with MgB_2 cable inside
  b. Lifting frame (SC link with DFHX) with unspooler – 50 kCHF
  c. SC link local fixed supports on platform, specific for IT String configuration – 15 kCHF
  d. Cable chain at DFX extremity, specific for IT String configuration – 27 kCHF
  e. Temporary platform at DFX extremity to support cable chain (unspooling phase) – 3 kCHF
  f. Cable chain fixed support (final position), specific for IT String configuration – 10 kCHF
- DFHX:
  a. Cryostat (pre-series) hosting the splices of MgB_2 cable to the HTS part of the current leads
  b. Chassis and parts for fixation to the IT String platform – xx kCHF
  c. Supports for proximity equipment on DFHX frame, IT String configuration – 10 kCHF
  d. Splitting module (v-taps, TT) at IFS outlet, see Section 3.3.1 of [4] – recovered for machine
  e. Thermoswitch box with the input cables, Section 3.3.3 of [4] – recovered fro machine
  f. Welding support from EN-MME – 5 kCHF
  g. IP protection cage, specific IT String – 50 kCHF
- DFHX cryogenics (contribution WP9)
  a. Gas Management system (GMS) – 181 kCHF
  b. He (cold) transferline DFHX to GMS, see Section 2.2 of [4], specific IT String – 15 kCHF ?
  c. He (warm) warm recovery lines DFHX current leads to GMS, specific IT String – 5 kCHF
- All ancillary equipment needed for operation and protection.
  a. Vacuum instrumentation, cabling, controls – VSC contribution
  b. Vacuum barrier bypass at DFX and DFHX – 6 kCHF
  c. Safety valves/burst discs – 6 kCHF – ok Yann

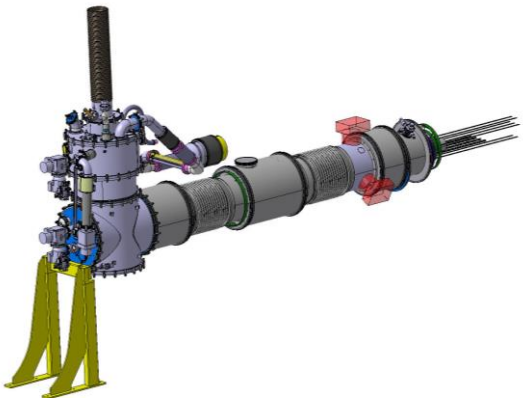

Figure 3: DFX (CAD image)

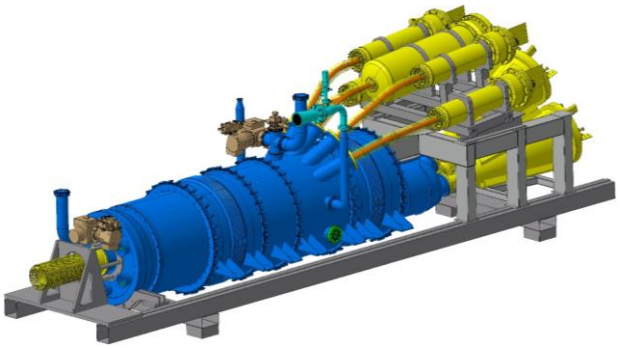

Figure 4: DFHX (CAD image)

4.3 Integration of Cold Powering hardware in the IT String

The DFHX and the DSHX will be placed on the HL-LHC IT String Metallic Platform, adapted to their requirements. On the other side, the DFX will be placed on the ground floor at the North-East extremity of SM18 building.

The integration of the equipment can be found in the following integration model (SmarTeam®): ST0898713_01 and [5], maintained by EN-ACE and being A. Kosmicki (antoine.kosmicki@cern.ch).
Figure 5 shows an integration drawing of the HL-LHC IT String in SM18, comprising the main Cold Powering elements.

Add here the reference for the platform loading (Nicolas to add)

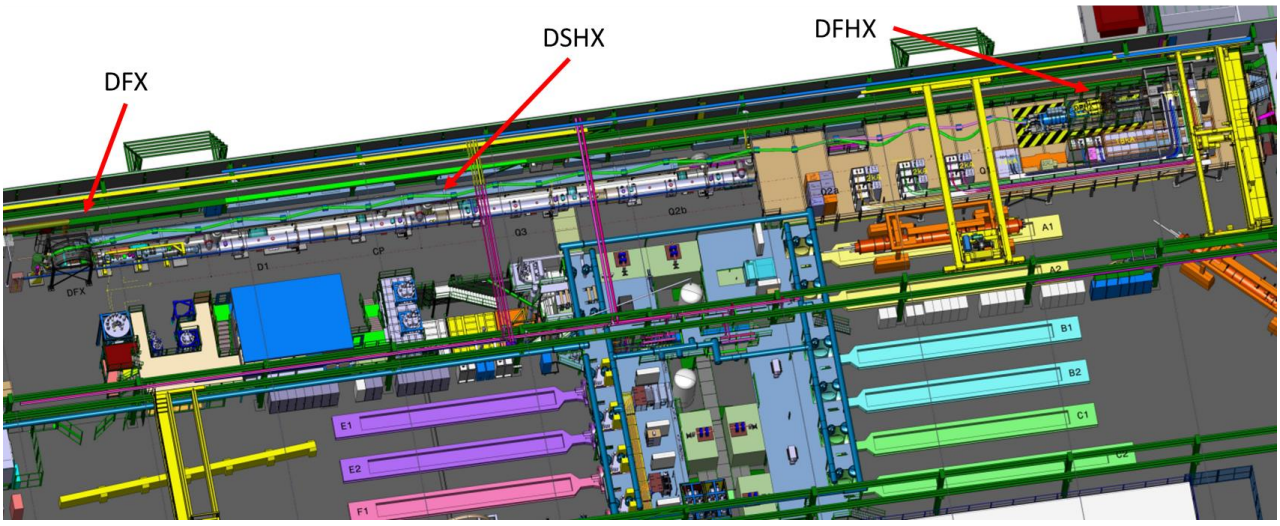

Figure 5: HL-LHC IT String Configuration in SM18. DSHX is the SC Link

4.4 Interfaces

The Cold Powering System presents several interfaces with elements from other WPs that are extensively reviewed in [4].

4.5 Equipment recovery

Part of the hardware used in the IT String will be recovered by WP6A for its use as LHC spare components. It is the case for DFX, DFHX and DSHX. Items that cannot be recovered, or are specific to the IT String configuration are listed, with their cost, in chapters 4.2 & 4.6

~~Nevertheless, the IT String Cold Powering equipment is not required for the HL installation (unless there is a major non-conformity with 1 of the 4 triplet Cold Powering Systems). As such,~~ Today there is not a specific requirement on the de-installation of the HL-LHC IT String , nor an extra cost linked to the doubling of the components to be procured. However, if a failure will happen during installation in the tunnel of the WP6a series components, the spare units shall be made available.

4.6 Requirements and needs for services

Cold Powering needs concerning electrical services, cooling and ventilation and controls can be found in the next subsections.

4.6.1 Cooling and ventilation services

Presently no particular cooling and ventilation services (demineralised water, compressed air, etc.) are requested by WP6A. However, cold tests of the Cold Powering System prior to installation in the String will confirm the possibility of operating the system withouth the dry-air bags today installed in the LHC tunnel for the operation of current leads in the DFBs. No cost or design associated at present (rework after)

4.6.2 Electrical services

WP6A requests regarding the following electrical equipment:

- Signal cabling: EN-EL-CS will coordinate a DIC through the SNOW ticketing system. The pre-DIC request by WP6A can be observed at [1]. The control cabling request is now in the responsibility TE-CRG and TE-MPE groups.
- Optical fibres: Not requested by WP6A.
- Power needs: EN-EL-EPM will coordinate an EDMS template. The power request by WP6A can be observed at [6].
- Cold Powering System at the IT String requires 15 kCHF for control cabling & 15 kCHF for AC cabling (wu 229564)

4.6.3 Controls requirements

The control principles that includes the carpenter list, purge and leak tests, cooldown, cold operation and warmup are specified in [7].

4.6.4 *Racks and space occupancy*

No racks requested. Should we say which racks are installed and by whom ? We have a lot of racks in the system. Add a clarification that this is referring to requests to EN/EL – not the local racks/proximity equipment.

4.6.5 *Handling Tools*

Several dedicated tools are required for cold powering system installation at the IT String:

Service name	Phase	Quantity / details
EN-HE-PO	Installation	Consolidate 1 overhead crane for IT String installation[ref]. Complete - 13 kCHF contribution from WP6a. (I thougth it was more. Is it 130 kCHF ?)
EN-HE-PO	Installation	Mobile crane to lift cable chain/SC Link during insertion into DFX

Table 1: Handling tools for IT String installation

5 COLD POWERING ACTIVITIES FOR THE IT STRING

The following chapter provides the breakdown of installation activities, including their duration and the industrial manpower needs. Unless otherwise stated, all WP6A contributions to WP16 requiring WP6A industrial manpower are complemented by 1.0 staff technician and 0.5 staff engineer (FTE in the year of installation ?). The man.hour integrals shown in Table X represent the cummulative activity durations multiplied by 2 to account for activity preparations, and on-site efficiencies.

Table X: Human resources for WP6a installation activities

WP6A Resource Name	Man.hours
WP6a Engineer - staff	550 hrs
WP6a Technician - staff	1100 hrs
WP6a Technician - industrial support	1100 hrs

5.1 Installation overview

Integration of the Cold Powering System at the IT String is expected according to the following sequence [REF]. If the delivery schedule of the magnets is advanced then the sequence can be modified:

- DFX - ~~Pre-assembly in laboratory~~ Installation
- DFHX+DSHX - Lifting to platform, fixation of DFHX, unspooling of SC Link
- DFX - SC Link insertion, DFX assembly (up to Nb-Ti/Nb-Ti interconnect)
- Triplets - Magnet installation including busbar inserion into line N
- DCM - Installation
- DFX - NbTi/NbTi connection, closure of interconnect

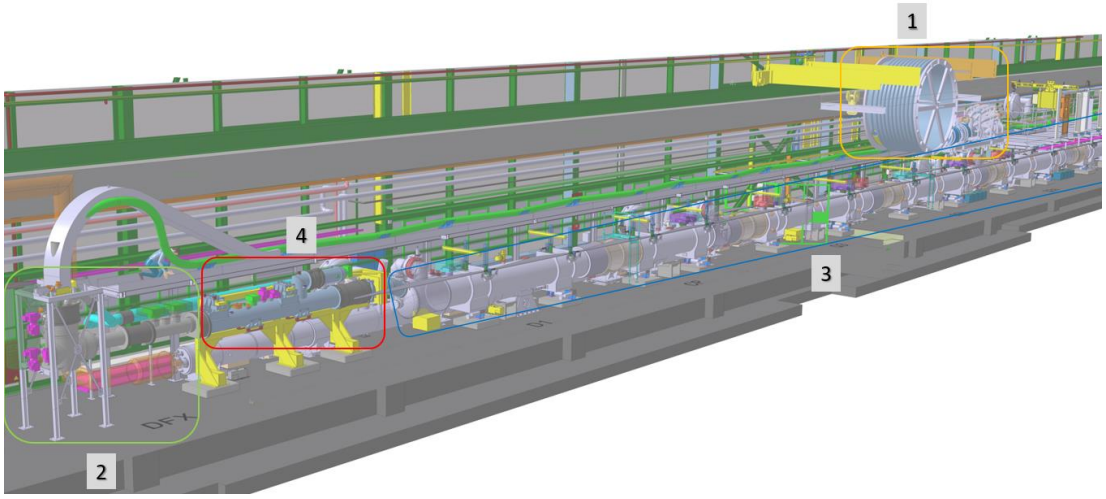

Figure x: Overview of the Cold Powering integration sequence at HL-LHC IT String

Installation of the Cold Powering System at the IT String builds upon the experience gained during the WP6A activity related to installation/deinstallation in the F2 test bench in SM18.

In order to determine the manpower requirements of the WP6a contribution, the following assumptions are made with respect to support teams:

- Integration: WP16 contribution
- Handling in SM18: EN-HE contribution in SM18 (up to 2 persons)
- Support frames & their installation: WP6a with EN-ACE
- DFX assembly work: WP6a team contribution
- Interconnection welding*: WP6a with EN-MME (alternatively via TE-MSC)
- DFX interconnection (NbTi/NbTi) : TE-MSC contribution
- Vac instrumentation & pumping: TE-VSC contribution
- Interconnection & global leak tests: TE-VSC contribution
- ELQA & electrical protection: TE-MPE contribution.
- Cryogenic signal conditioning TE-CRG contribution

*includes welding of: DFX assembly; DFX interconnect; DFX-SQXL transfer line; DFHX-GMS transfer line

5.1.1 DFX pre-assembly

Task Name	Duration	Industrial Support Technicians		
DFX installation preparation	**2.5 days**	**EN-HE**	**EN-ACE**	**WP6a**
Install DFX support frame	0.5 days	✓	EDH job	1
Mount DFX vertical cryostat [x]	2 days	✓		1
IS Totals				**2.5 days**

Table x: DFX pre-assembly activities

5.1.2 DFHX-DSHX Installation

Task Name	Duration	Industrial Support Technicians		
DFHX-DSHX installation preparation		**EN-HE**	**EN-ACE**	**WP6a**

Install temporary extension* Sc link tray	2 days	✓	EDH job	1
Install cable chain on Sc link tray	0.5 days	✓		1
Install DSHX fixed supports	2 days	✓	EDH job	1
DFHX-DSHX installation				**4.5 days**
Transfer to String zone	1 day	✓		1
Installation of lifting frame	2 days	✓		1
Lifting DFHX-DSHX onto platform	1 day	✓		1
Fixation of DFHX to platform	1 day	✓		1
Unspooling DSHX	1 day	✓		1
Removal of lifting frame & spool	1 day	✓		1
IS Totals				**7 days**

Table x: DFHX-DSHX installation activities

*Temporary extension of SC Link tray to support MgB_2 splices & NbTi extensions after unspooling

5.1.3 DFX Assembly (up to NbTi/NbTi interconnect)

The DFX cryostat is assembled in-situ in a multi-step sequence [ref]. Figure xx shows the main sub-assemblies. 'DFX-V' is already in place following the activities of section 5.1.1. The scope of this section includes the insertion of the SC link, assembly of the 'DFX-V low elbow' and the 'DFH-h link side'

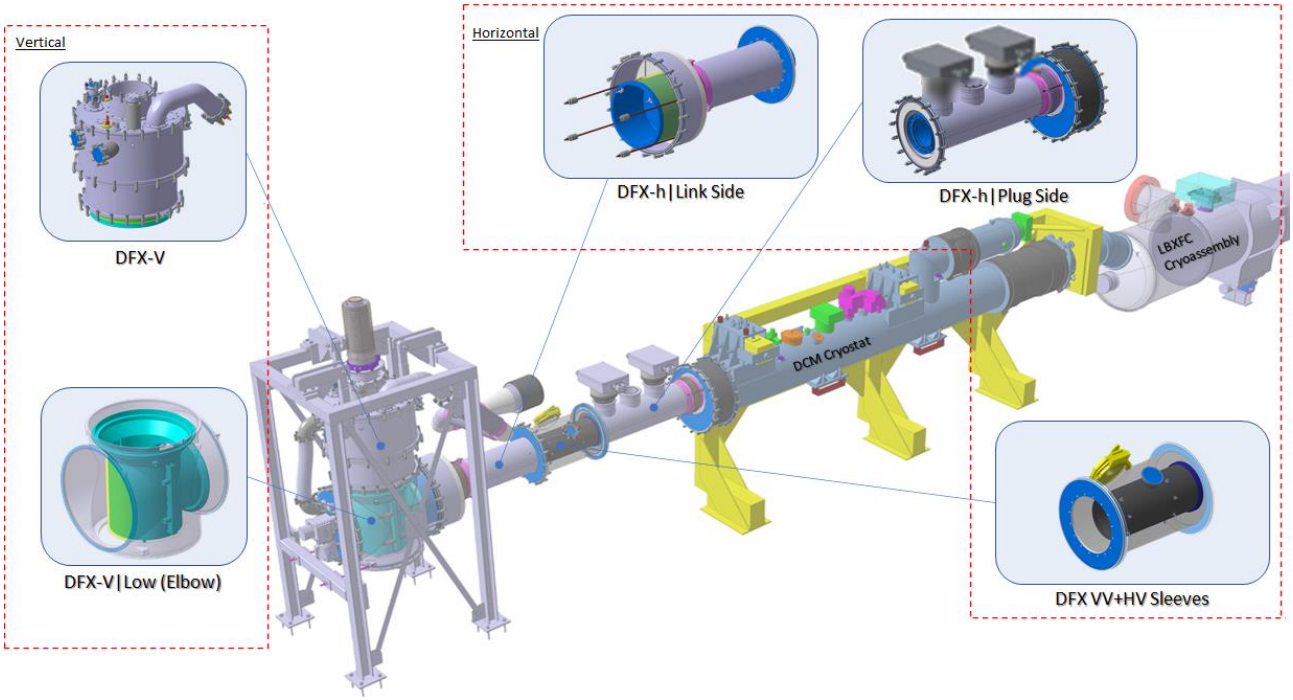

Figure xxx: DFX main subassemblies

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Task Name	Duration	Industrial Support Technicians				
DFX Assembly		**EN-HE**	**TE-MPE**	**EN-MME***	**TE-VSC**	**WP6a**
DFX-V						
Insert Sc link in DFX top flange	2 days	✓				1
Install the cable chain support	1 day	✓				1

Electrical tests	0.5 days		✓			1
Weld Sc link to DFX top flange	1 day			EDH job		1
Leak test above weld	0.5 days				✓	1
'DFX-V' finalisation	2 days	✓				1
DFX-V low elbow						
Form NbTi extensions	1 day	✓				1
Electrical tests	0.5 day		✓			1
Install low elbow	1 days	✓				1
Weld low elbow to DFX-V	1 day			EDH job		1
Leak test above weld	0.5 day				✓	1
DFX-V low elbow finalisation	2 days					1
DFX-h link side						
Install DFH-h subassembly	1 days	✓				1
Weld DFH-h to DFX-v elbow	1 day			EDH job		1
Leak test above weld	0.5 day				✓	1
DFX-h finalisation	2 days					1
IS Totals						**17.5 days**

*Welding support from EN-MME (baseline) or TE-MSC to be clarified

Table x: DFX assembly activities (up to NbTi/NbTi interconnect)

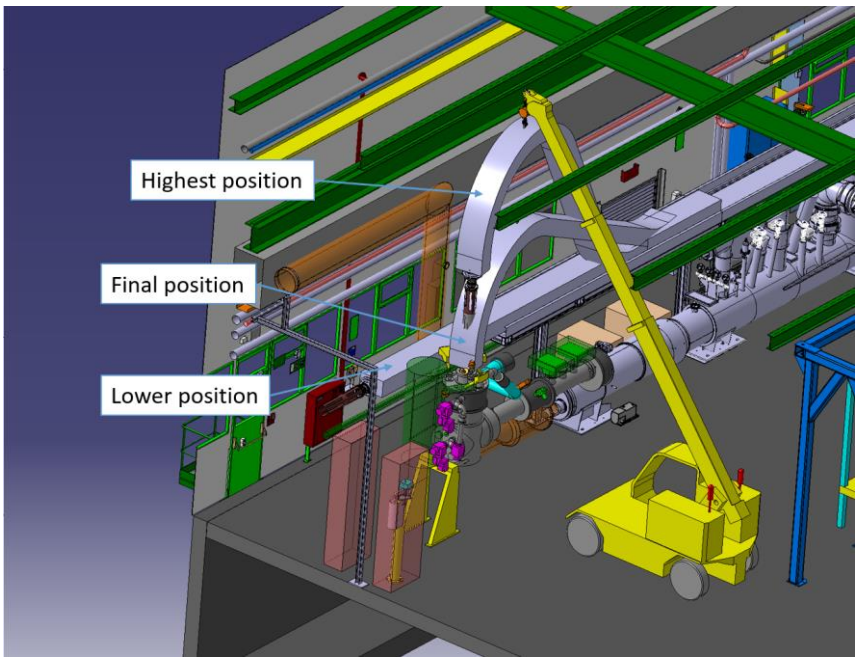

Figure bbbb: Insertion of the Sc link in DFX top flange using cable chain

5.1.4 DCM Installation

The DCM is not within the scope of WP6A, however it interfaces directly with the DFX [ref]. Figure y show a schematic representation, with the NbTi cables of the DCM entering the DFX upto the NbTi/NbTi interconnection.

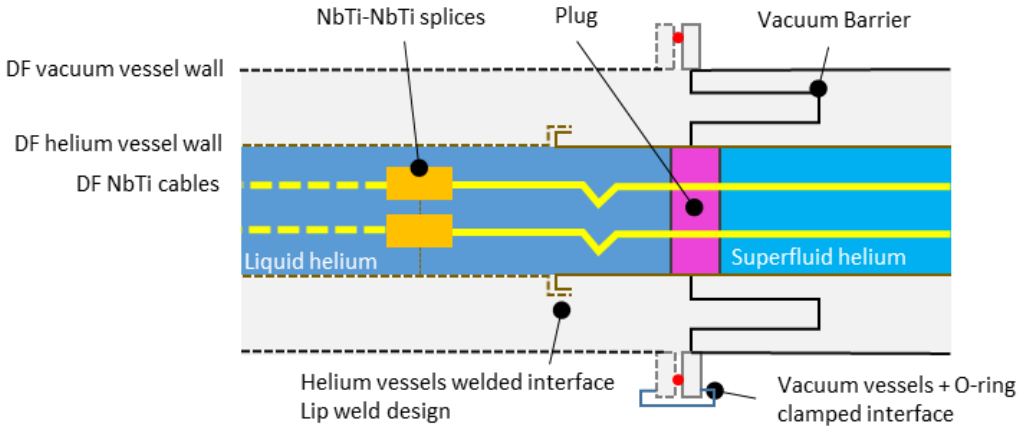

Figure y: Schematic of the DFX-DCM interface. Dashed lines represent the DFX

The 'DFX-h plug side' sub-assembly, illustrated in figure xxx, is slid over the ~2 m NbTi cable extensions protruding from the DCM plug. For the IT String and HL-LHC machine configurations, the 'DFX-h plug side' subassembly is joined to the DCM at the helium vessel and vacuum vessel interfaces prior to the DCM installation.

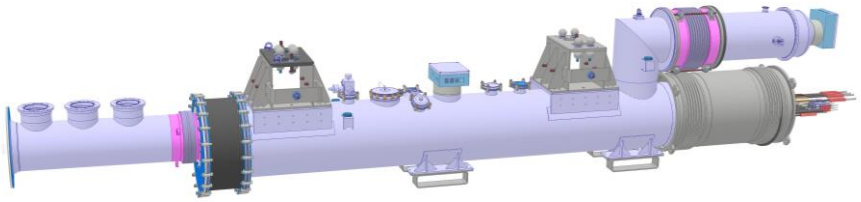

Figure yyy: Subassembly of the DCM with 'DFX-h plug side'

The DCM subassembly, with the DFX-h plug side appendage, cannot be installed until the line N is inserted into the complete string of cryomagets. WP6a will support the WP3 team installing the DCM subassembly, as detailed in table zzzz

Task Name	Duration	Industrial Support Technicians		
DCM installation		**EN-HE**	**TE-MPE**	**WP6a**
Remove protections at 'DFX-h link side'	0.5			1
Install DFX interconnection sliding sleeves	0.5	✓		1
Electrical tests	0.5 day		✓	1
Safely position NbTi & instrumentation cables	1 day			1
Install DCM subassembly (led by WP3)	1 day			1
IS Totals				**3.5 days**

Table zzzz: WP6a support to DCM installation.

5.1.5 DFX NbTi/NbTi interconnection

NbTi cables from the Sc link via the DFX are spliced to NbTi cables from the DCM in the horizontal interconnect of the DFX. In the same interconnect, instrumentation cables (v-taps, temp sensors) routed from the two IFS on the 'DFX-h plug side' are joined with those from the 'DFH-h link side'.

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Task Name	Duration	Industrial Support Technicians

DFX NbTi/NbTi interconnection		TE-MSC	TE-MPE	EN-MME*	TE-VSC	WP6a
Splicing of NbTi/NbTi (TE-MSC)	4 days	✓**				1
Electrical tests	1 day		✓			1
Instrumentation connection	2 days					1
Electrical tests	1 day		✓		✓	1
Weld helium sleeve	1 days			EDH job		1
Leak test helium sleeve	0.5 day				✓	1
Close interconnect	0.5 day	✓				1
IS Totals						**10 days**

*Welding support from EN-MME (baseline) or TE-MSC to be clarified
**Interconnection splicing trials will be required by TE-MSC

Table x: DFX NbTi/NbTi interconnection

5.2 Installation connections at DFHX

After installation of the DFHX on the String platform, several connections are required. The detailed sequencing of these activities is to be defined. Table xxx does not represent the chronological order, and some activities can be made in parallel.

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Task Name	Duration		Industrial Support Technicians					
DFHX installation connections		**SY-EPC**	**TE-MPE**	**EN-MME**	**EN-HE**	**EN-EL**	**EN-ACE**	**WP6a**
18 kA leads to busbars	2 days	✓			✓			1
7 kA & 2 kA leads to ACC	2 days					✓		1
Current leads (warm He) to GMS	2 days							1
DFHX (cold He) to GMS + welding	2 days			EDH job				1
Vacuum instrumentation	2 days							1
Proximity equipment supports	1 day				✓			1
Splitting box at DFHX IFS	2 days		✓					1
CL heaters & thermoswitch box	2 days		✓					1
IP2x cage installation	5 days				✓		EDH job	1
IS Totals								**20 days**

Table x: Installation connections at DFHX

5.3 Installation connections at DFX

After installation of the DFX, several connections are required. The detailed sequencing of these activities is to be defined. Table xxx does not represent the chronological order, and some activities can be made in parallel.

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Task Name	Duration	Industrial Support Technicians				Led by:
Installation connections at DFX		**EN-MME***	**TE-VSC**	**TE-MPE**	**WP6a**	
DFX-SQXL transfer line install/weld	1 day	EDH job			1	WP6a
DFX-SXQL tranfer line l.test	1 day		✓		1	WP6a
Vacuum instrumentation	1 day		✓		1	TE-VSC
Connection at DFX IFS	1 day			✓	1	WP7
IS Totals					**4 days**	

*Welding support from EN-MME (baseline) or TE-MSC, to be clarified.

Table x: Installation connections at DFX

5.4 System commissioning

Several ATS Groups and HL Workpackages contribute to the individual system tests and commissioning of the fully installed Cold Powering System at the IT String. These costs are integrated in dedicated contribution documents of each Group.

Table 2: Human resources allocation

WP6A Resource Name	Work
WP6a Engineer - staff	628.8 hrs
WP6a Technician - staff	856 hrs
WP6a Technician - industrial support	232 hrs

6 SCHEDULE

The current baseline schedule of the HL-LHC IT String [7] integrates the different activities of WP6A described on this document.

7 COST AND RESOURCES (CHAPTER IN 1ST VERSION OF SALVA DOC)

7.1 Cost estimate

Considering the baseline configuration shown in Figure 1, Tables 3 and 4 provide with the corresponding cost estimate for the magnets contribution, according to baseline 5.2.

- The cost for the installation and commissioning of the IT String amounts to 7.07 MCHF.
- The total cost of the Cold Powering contribution (*installation, commissioning, experimental program*) is 345 kCHF.
- The cost of de-installation for the Cold Powering System, although not in the scope of WP16, is XX kCHF.
- These costs must cover all hardware specific to the IT String such as cables. Services such as power are provided by WP16. Transport to SM18 and from SM18 is under each contributors' responsibility.

Table 3: Baseline configuration – Hardware and M4P costs

Material (kCHF)	**M4P (kCHF)**
180	165

Summary table of the contribution of the Cold Powering System.

The resources needed to perform Cold Powering activities in the IT String for all phases, including its de-installation are presented in Table 4.

Table 4: (table inserted by Salva to cancel) FTE of Staff per year

Group/Section	2018	2019	2020	2021	2022	2023	2024	Total (FTE·years)
TE-MSC	0.2	0.2	0.3	0.5	0.3	0.2	0.2	**1.9**

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**

7.2 EVM and budget codes

The WBS containing the workunits for Cold Powering is HLLHC 16.1.3 - IT String & Hardware commissioning - IT String – Cold Powering System. The related WUs have been declared in EVM, and they are available via [8]. The summary of budget codes is given in Table 8.

Table 5 - Budget codes and work units for the Cold Powering contribution to WP16

Work unit	Budget code
220228 - HL-LHC-WP16-M4P-IT String & HardwareCommissioning- IT String Cold Powering	92591 – HL-LHC WP16-IT-String (Personnel)

229564 - HL-LHC-WP16-M-IT String & HardwareCommissioning-IT String Cold Powering System	92671 – HL-LHC WP16-IT String-Cold Powering System

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[3] WP6A Controls request for the IT String

[4] WP6A Racks request (DIR) for the IT String

[5] HL-LHC IT String Baseline 1

https://edms.cern.ch/document/2583817

[6] APT CERN

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