DFX Functional Specification

Y.Leclercq on behalf of the DF development team WP6a
20 June 2019

Detailed design review of the DFX

DFX in Cold Powering System

Each IP1 and IP5 sides equipped with a cold powering chains of cryostats

- Triplet insertion : DFHx – SC Link (DSH) – **DFX**

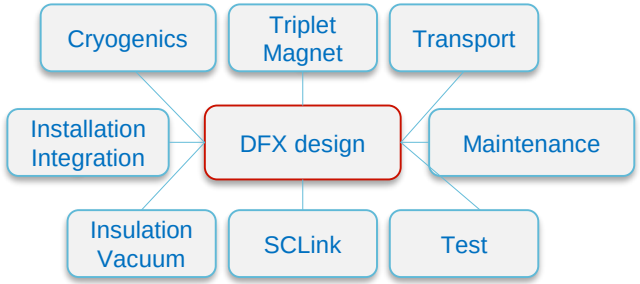
DFX basic functions:

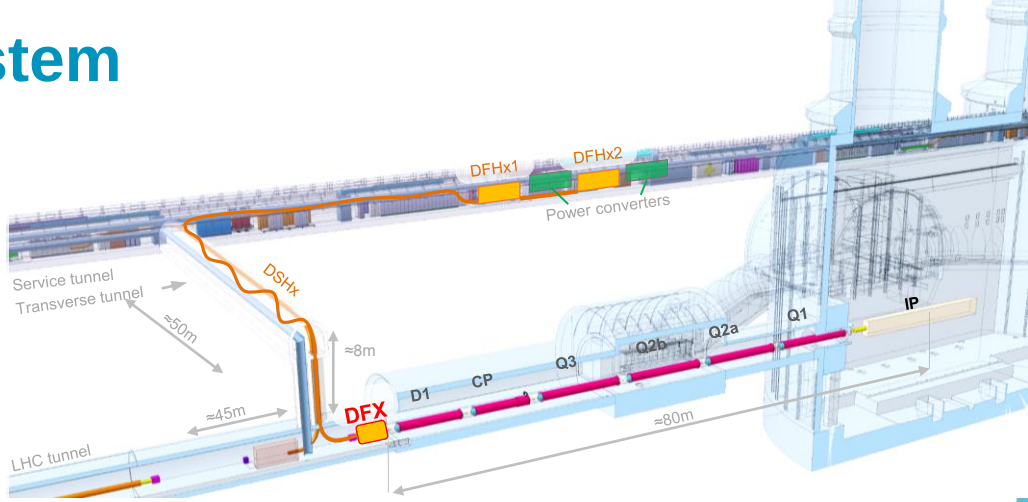
- Electrical interface between SC Link and superconducting magnets
- Supply cryogenics to the SCLink

System Interfaces

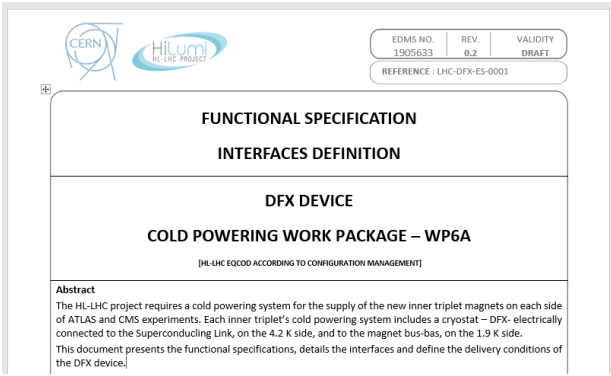
DFX functional specification : Inputs for design EDMS1905633

DF system interfaces





DFX functional specification EDMS 1905633



EDMS NO. 1905633 | REV. 0.2 | VALIDITY DRAFT

REFERENCE : LHC-DFX-ES-0001

FUNCTIONAL SPECIFICATION

INTERFACES DEFINITION

DFX DEVICE

COLD POWERING WORK PACKAGE – WP6A

[HL-LHC EQCOD ACCORDING TO CONFIGURATION MANAGEMENT]

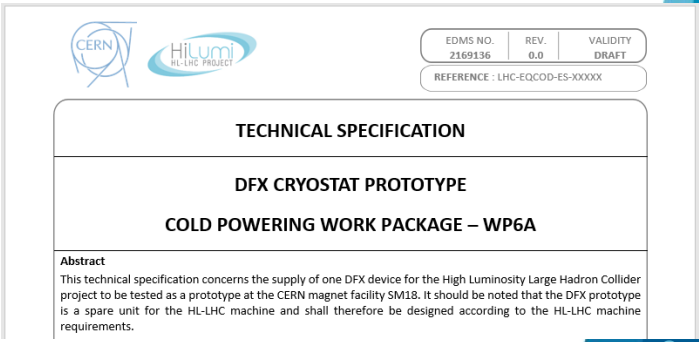
Abstract

The HL-LHC project requires a cold powering system for the supply of the new inner triplet magnets on each side of ATLAS and CMS experiments. Each inner triplet's cold powering system includes a cryostat – DFX- electrically connected to the Superconducting Link, on the 4.2 K side, and to the magnet bus-bas, on the 1.9 K side.

This document presents the functional specifications, details the interfaces and define the delivery conditions of the DFX device.

General functional requirements

- DFX prototype installed in LHC machine as spare
- Applicable rules and standards defined in the Technical Specification (see dedicated talk and dedicated document)



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REFERENCE : LHC-EQCOD-ES-XXXXX

TECHNICAL SPECIFICATION

DFX CRYOSTAT PROTOTYPE

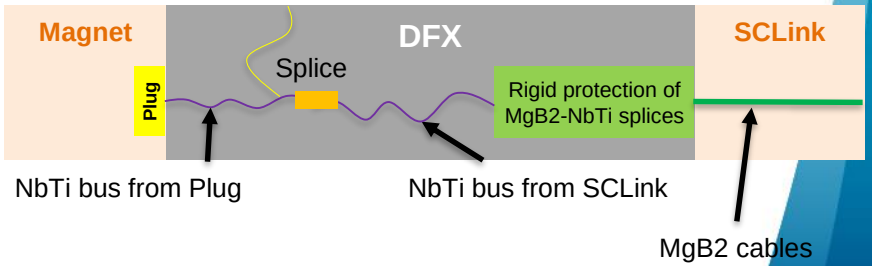
COLD POWERING WORK PACKAGE – WP6A

Abstract

This technical specification concerns the supply of one DFX device for the High Luminosity Large Hadron Collider project to be tested as a prototype at the CERN magnet facility SM18. It should be noted that the DFX prototype is a spare unit for the HL-LHC machine and shall therefore be designed according to the HL-LHC machine requirements.

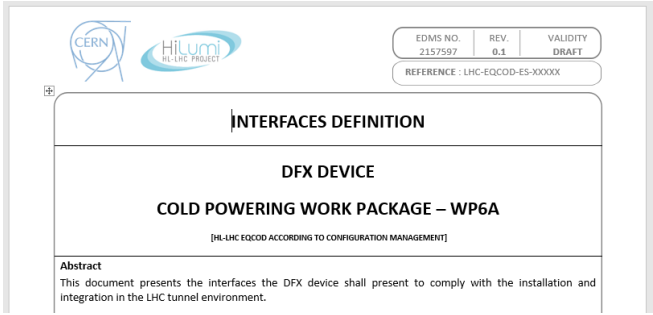
Electrical main specifications

- DFX shall ensure the electrical connectivity between the SCLink and triplet cables
- SCLink cables layout:
  - 19 MgB2 conductors in SCLink
  - NbTi extensions soldered to MgB2 in protective rigid cylinder
  - Only NbTi extensions are accessible in DFX
- Magnet cables layout: 19 NbTi conductors from magnet side through Lambda Plate
  - (details on bus bars, Lambda plate, see dedicated talks)
- The NbTi extensions shall be routed and connected to the NbTi bus coming out from the plug
- Instrumentation shall be routed to feedthroughs on a dedicated patch panel at the level of the vacuum vessel interface (no cold feedthroughs, see dedicated talk)



Mechanical interfaces

- Mechanical interfaces : dedicated talk and document EDMS2157597
- Functional requirements for interfaces:
  - DFX shall be assembled / disassembled up to 5 times
  - SCLink
    - Vacuum & Helium flanges fixed to DFX
    - Only NbTi extensions access the DFX He volume
  - Magnet mechanical interface
    - Plug fixed to ground
    - DFX shall present flexible elements
    - Access to NbTi-NbTi splices granted during installation and maintenance
  - Cables thermal contractions
    - NbTi-NbTi splices fixed to DFX He vessel
    - DFX covers internal contractions 3.5 mm/m
    - DFX shall allow NbTi extensions to move 50 mm into the splices protection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INTERFACES DEFINITION

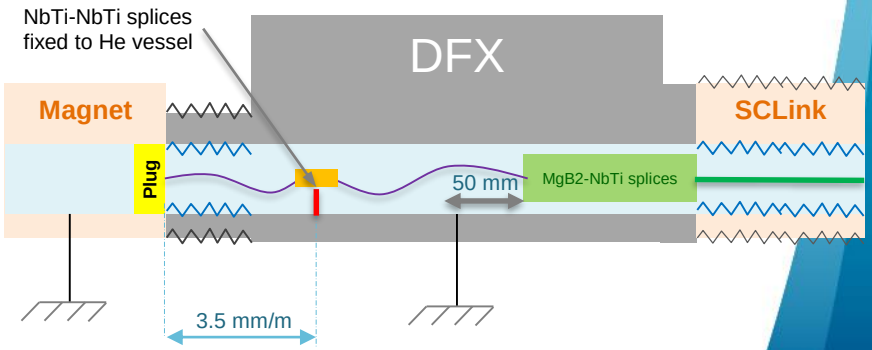
DFX DEVICE

COLD POWERING WORK PACKAGE – WP6A

[HL-LHC EQCOD ACCORDING TO CONFIGURATION MANAGEMENT]

Abstract

This document presents the interfaces the DFX device shall present to comply with the installation and integration in the LHC tunnel environment.



Cryogenics requirements

Dedicated presentations on Cryogenic scheme, operation, safety

Layout:
- Hydraulic plug separates triplet magnet & DFX-SCLink He volumes
- Dedicated DFX jumper

Electrical performance:
- NbTi cables & MgB2-NbTi splices immersed in LHe

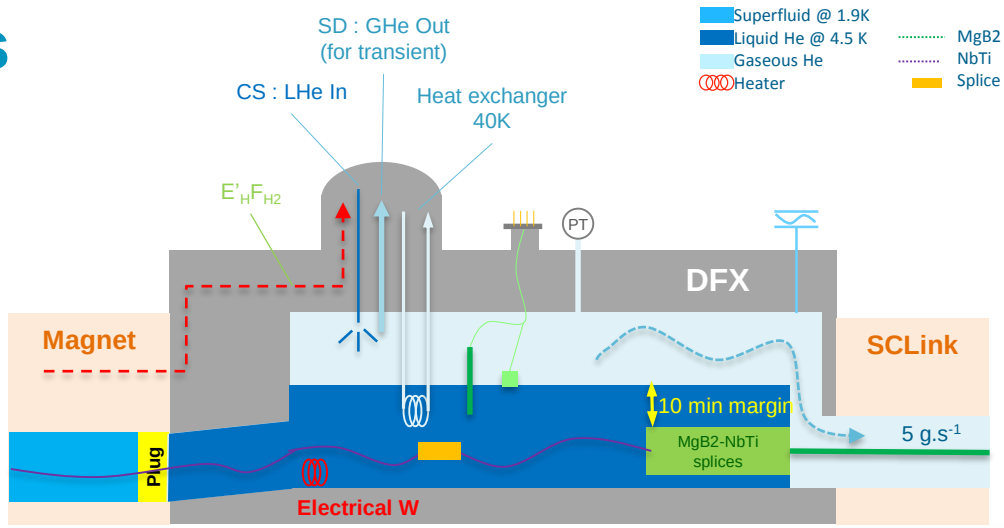
Cryogenic lines:
- LHe in, Ghe out, heat exchanger, Outlet Magnet line (in discussion)

Operation configuration
- Heaters (electrical & heat exchanger) vaporises helium
  - Nominal : 5 g.s^{-1} , design 10 g.s^{-1}
- Ghe gaseous mass flow through the SCLink
- Design pressure : 2.5 bara (nominal 1.3 bara)

Instrumentation:
- Level gauges, Temperature sensors, Pressure gauge as defined in Instrumentation Talk

Design requirements:
- Heat loads to LHe < **30** W
- No condensation on external surfaces and feedthroughs
- Electrical heaters at lowest position for LHE vaporisation during WU
- > **10 min** of nominal supply GHE in case of liquid supply stop
- > **10 min** of immersion of splices in case of liquid supply stop
- Constant slope between coldest point and LHE-GHE interface
- Safety relief devices to protect DFX+SCLink

Access to safety relief devices, instrumentation interfaces shall be granted for inspection and maintenance



DFX nominal configuration

Detailed levels, volumes and dimensions requirements §3.3.5

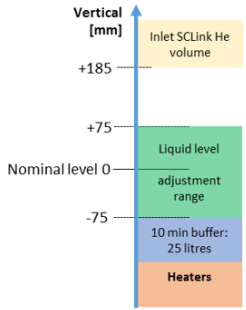


Figure 2a: levels and volumes for production and control of required mass flow

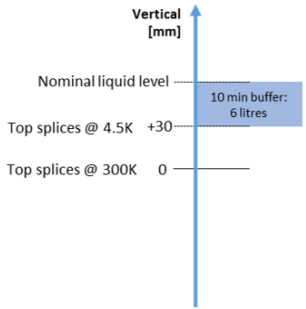


Figure 2b: levels and volumes for the immersion of splices

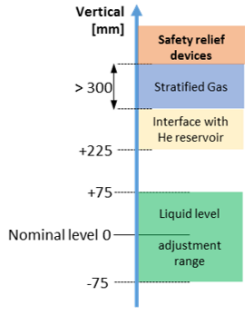


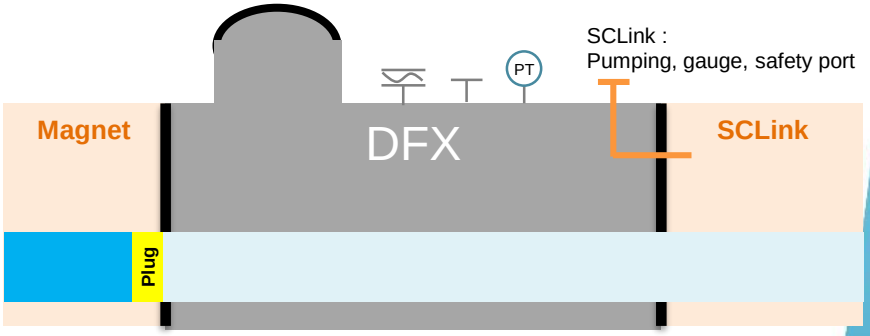
Figure 2c: levels and volumes for location of safety relief devices

Insulation vacuum

- The DFX insulation vacuum shall be compatible with the General WP6a insulation vacuum layout EDMS 2048016
- The DFX insulation vacuum is independent to:
  - Allow local maintenance & leak detection
  - Minimise inter-dependence between helium volumes
- ➔ DFX presents vacuum barriers with:
  - The cryolines (not part of DFX)
  - The SCLink (part of the DFX)
  - The triplet cryostat (not part of SCLink)
- Interfaces see dedicated talk

Table1 : Insulation vacuum requirements for WP6a components

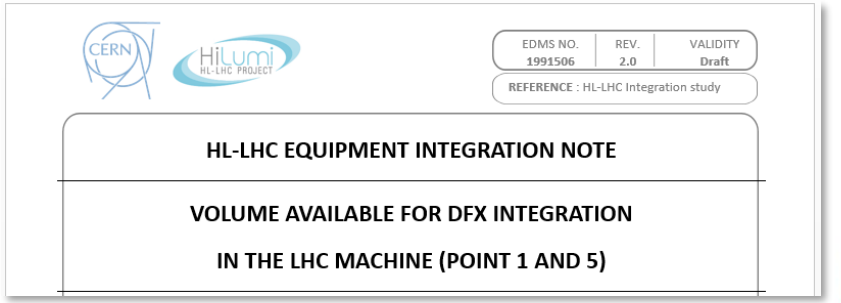
Unit	Value
Insulation vacuum pressure level at ambient temperature	$< 1.10^{-4}$ mbar
Insulation vacuum pressure level in nominal operation	$< 1.10^{-5}$ mbar
Maximum allowed overall leak rate in nominal operation	$< 2.10^{-8}$ mbar.l.s^{-1}

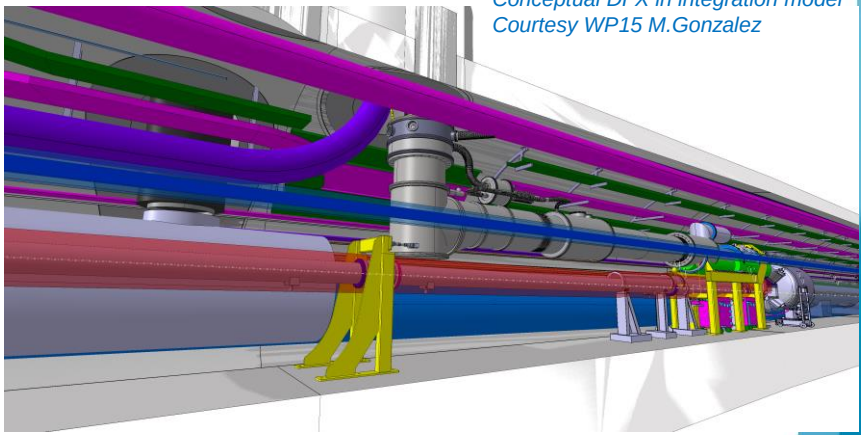


Integration specification

EDMS 1991506

- Recommendation from CDR to integrate known boundaries in the functional specification
  - ➔ key inputs included and detailed
    - §3.5 Integration & installation
      - 3.5.1 Tunnel environment
      - 3.5.2 Accessibility during installation and maintenance
      - 3.5.3 Access limitations in the tunnel
      - 3.5.4 Mechanical interfaces
  - ➔ document from WP15 remains the reference document concerning integration volumes
- Tunnel integration : See dedicated talk
- Mechanical interfaces : See dedicated talk

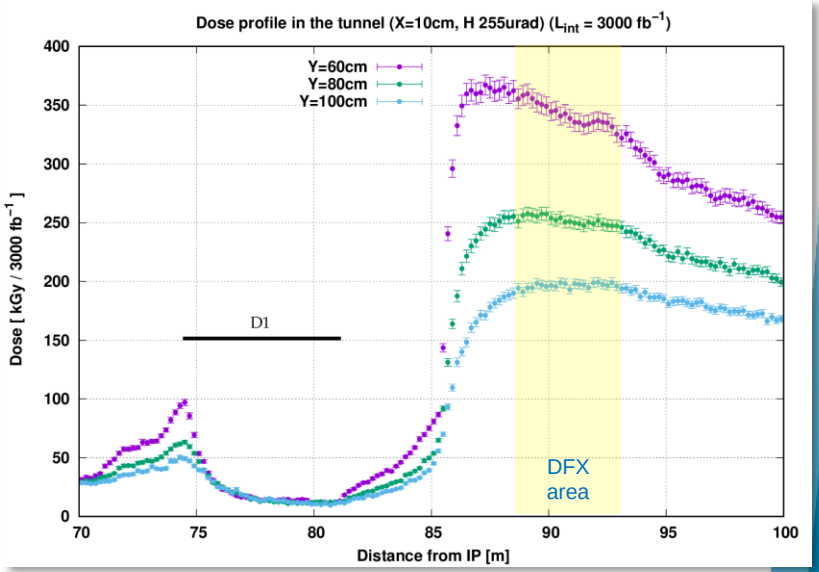




Conceptual DFX in integration model
Courtesy WP15 M.Gonzalez

Preventive maintenance and repairs

- All operations shall be designed from the ALARA point of view:
  - Minimise intervention time (access, automatic operation)
- Interventions
  - Unscheduled interventions for inspections and light work during Technical Stops (e.g. for electrical checks on patch panel)
  - Planned interventions for routine maintenance requiring warm up during YETS (e.g. replacement of burst disks)
  - Unscheduled medium repair work interventions requiring warm up during YETS (e.g. Nb-Ti/Nb-Ti repair)
  - Unscheduled heavy repair work interventions requiring warm up during EYETS or unscheduled extended machine stop (e.g. MgB2/Nb-Ti repair, plug replacement)



See : R.Garcia : LHC and HL-LHC: Present and future radiation environment in the high-luminosity collision points and RHA implications

Manufacturing & Inspections

- Moved to dedicated Technical Specification document
- See dedicated talk

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Summary

- Functional specification updated
- Manufacturing, qualification requirements moved to dedicated technical specification
- Interfaces moved to dedicated Interface specification