

WP6a Master Plan, Key Milestones Functional requirements DFX Within WP6a System

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DFX Conceptual Design Review, CERN, 31/01/2019

Outline

- Introduction WP6a overview
- DFX Functional requirements
- DFX Design evolution
- WP6a Master Plan and Key Milestones
- Conclusions



The HL-LHC Cold Powering (WP6a)

- Four Cold Powering Systems in total
- Two different types of Cold Powering Systems (one for the Triplets and one for the Matching Sections (D2 and its correctors)
- Systems for ITs and MSs identical at P1 and P5





Focus of this review is on the systems powering the Triplets



The HL-LHC Cold Powering (WP6a)

Cold powering system for HL-LHC Triplets:

- One SC Link;
- One **DFX**;
- One DFHX;
- All current leads for Triplets;
- All required ancillary equipment.



The HL-LHC Cold Powering System





Electrical circuits: Triplets



One main 18 kA circuit Three Trims: 2×2 kA (Q1 and Q3) 1×0.035 kA (Q1a)

Baseline established in May 2017

In addition: D1, Orbit Correctors and Higher Order Correctors individually powered





HL-LHC Triplets – Number of cables/splices EDMS 1821907

		Magnet	Cold Powering													
ſ		I _{ult} (kA)	I _{peak} (kA)	I _{lead} (kA)	I _{cable} (kA)	N _{leads} /N _{cables}										
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	Trim Q3	2	6.8	2*	7	1										
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	MCBXFB	1.59	-	2	2	2+2										
	MCBXFA	1.73	-	2	2	2										
	MCBXFA	1.59	-	2	2	2										
T	D1	12.96	-	18	18	2										

4×	18 kA
3×	7 kA
12	imes 2 kA



DFX Functional Requirements



DFX – Main functionalities/characteristics

- Cryostat, in the LHC tunnel, between the SC Link and the magnet chain
- It hosts the electrical splices between the Nb-Ti, exiting the link, and the Nb-Ti coming bus-bar passing through the λ -plate
- It provides the 4.5 K liquid helium bath (1.3 bar), inside which the Nb-Ti to Nb-Ti splices are submerged. A λ-plate separates the 4.5 K bath from the 1.9 K superfluid He environment (cold diodes box)
- It generates the ~ 5 g/s of maximum helium mass flow rate required for cooling the SC Link and the current leads
- It mechanically interfaces with the cryostat of the SC Link, on the SC link' side, and with the diodes cold box on the magnets' side
- It has vacuum barriers that separates its vacuum from the magnets' and from the SC Link's vacuum



DFX – Accessibility requirements

- **Interventions** to verify leak tightness and inspect pumping equipment, to check instrumentation cables can take place (inspections and light work, typically during LHC Technical Stops)
- Routine maintenance to change burst disks
- Exceptional external interventions to change LHe level gauges that produce the He mass flow (two will be installed for redundancy)

None of the above interventions requires opening the DFX. They require standard procedures and tooling. ALARA to be respected

Exceptional major interventions in the tunnel for the unlike case that a splice has to be repaired shall be possible. This applies to both Nb-Ti to Nb-Ti and MgB₂ to Nb-Ti splices. Also, replacement of λ-plate shall be possible. ALARA to be respected



DFX Design Evolution



DFX Design Evolution





Hillin both cases, MgB₂ to Nb-Ti splices done in the tunnel inside the DFX

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DFX Interface to SC Link – Design Evolution

Incorporation at the cold of the SC Link of an *ad-hoc* designed **termination containing the MgB₂ to Nb-Ti splices**



Main advantages:

- MgB₂ to Nb-Ti splices done in the lab and incorporated in the SC link (not part of the DFX anymore);
- MgB₂ to Nb-Ti splices tested and qualified with the link before installation in the tunnel

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A. Ballarino, WP6a Meeting, 19/07/2018

Left: Blue = flexible inner and outer pipes of SC Link cryostat (outer pipe external diameter ≤ 200 mm); orange = stainless steel cylinder containing the MgB2 to Nb-Ti splices; violet envelope = MgB₂ cable assembly; grey envelope = MgB₂ to Nb-Ti splices; red lines = flexible Nb-Ti cables coming out from the orange stainless steel cylinder; green = stainless steel cylinder. **Right:** in the volume inside the orange rigid cylinder the MgB₂ cables are opened and connected to Nb-Ti cables).The maximum external diameter is about 220 mm.





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Retained design

SC Link Cryostat Interface to DFX



Nb-Ti flexible termination



WP6a Schedule and key milestones



WP6a Master Plan

	Master plan	201	18	2019	2020	2021	2022	2023	2024	2025	
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WP6a Master Plan

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WP6a Key Milestones

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DFX in WP6a Master Plan

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Proto: full scale system with all components – including DFX String: full scale system with all components – including DFX A. Ballarino

DFX Prototype – UK Collaboration

- The DFX design is being performed in the framework of the HL-LHC UK collaboration
- The design work is done by the colleagues at the Univ. of Southampton in close contact with WP6a – weekly meetings and discussions – and WP15 (tunnel integration/accessibility aspects taken into account from the early stage of the design)
- The DFX being designed shall meet all requirements for installation/operation in the tunnel – it is in fact a spare unit for LHC



Conclusions

- A significant **progress** has been made in the last year on the **conceptual design** of the DFX
- The proposed design takes into account **requirements from SC** Link/Cables/Splices integration and operation – including protection aspects and related instrumentation
- The proposed design takes into account tunnel integration aspects
 The status of the work is at the conceptual level. Provided no showstoppers will be found, the detailed design will start in February 2019 aiming at a detailed design review by end of March 2019





Thanks for your attention !



Organogram WP6a



Infrastructures

Bldg. 927 Bldg. 163 Bldg. 288 SM-18	SMI 2
DSH Wire&Cables HTS Systems test	DFX
Leads Splices Leads	DFH

IL-LHC PROJ



S. Claudet

A. Ballarino, last updated: October 2018