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

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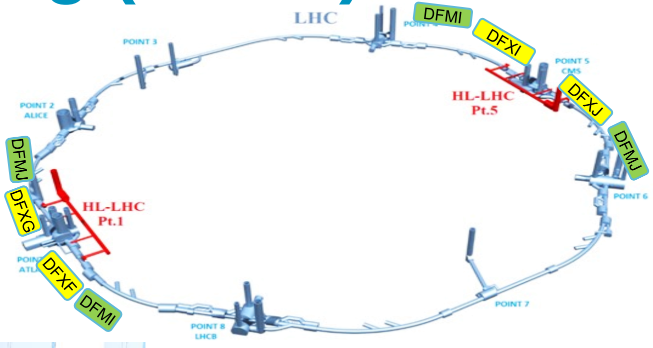
For the WP6a

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

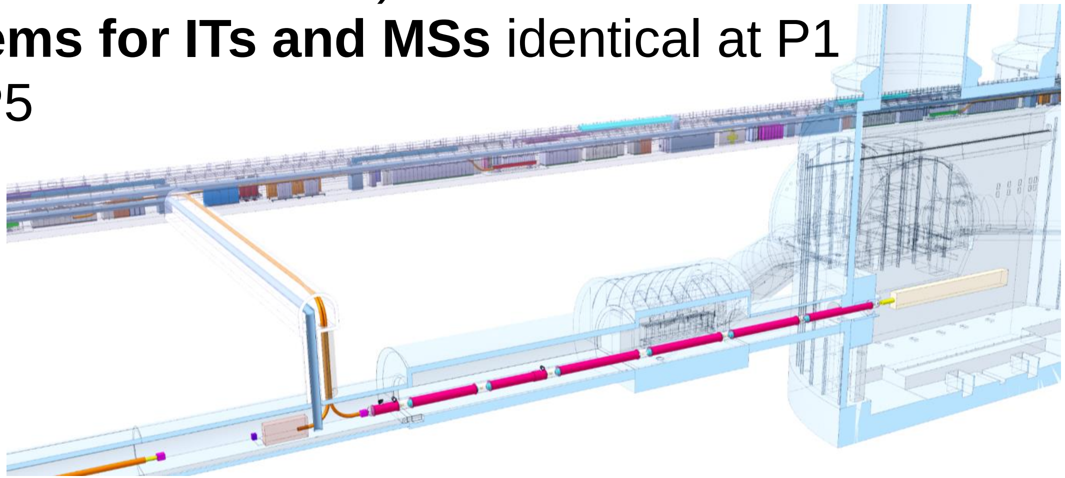
Outline

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

The HL-LHC Cold Powering (WP6a)

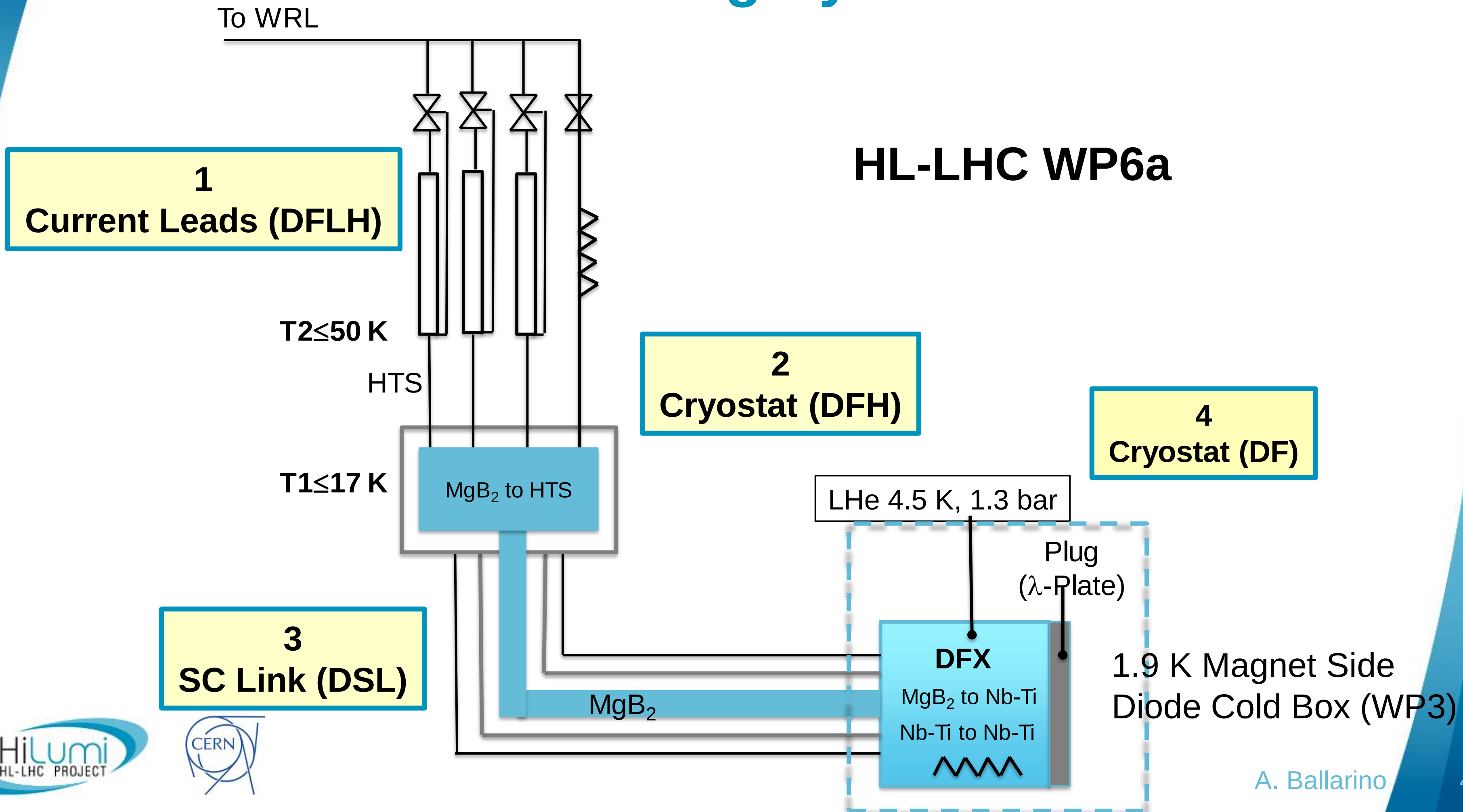


- **Four Cold Powering Systems** in total
- **Two different types** of Cold Powering Systems (one for the Triplets and one for the Matching Sections (D2 and its correctors)
- **Systems for ITs and MSs** identical at P1 and P5



Focus of this review is on the systems powering the Triplets

HL-LHC Cold Powering System: Schematic

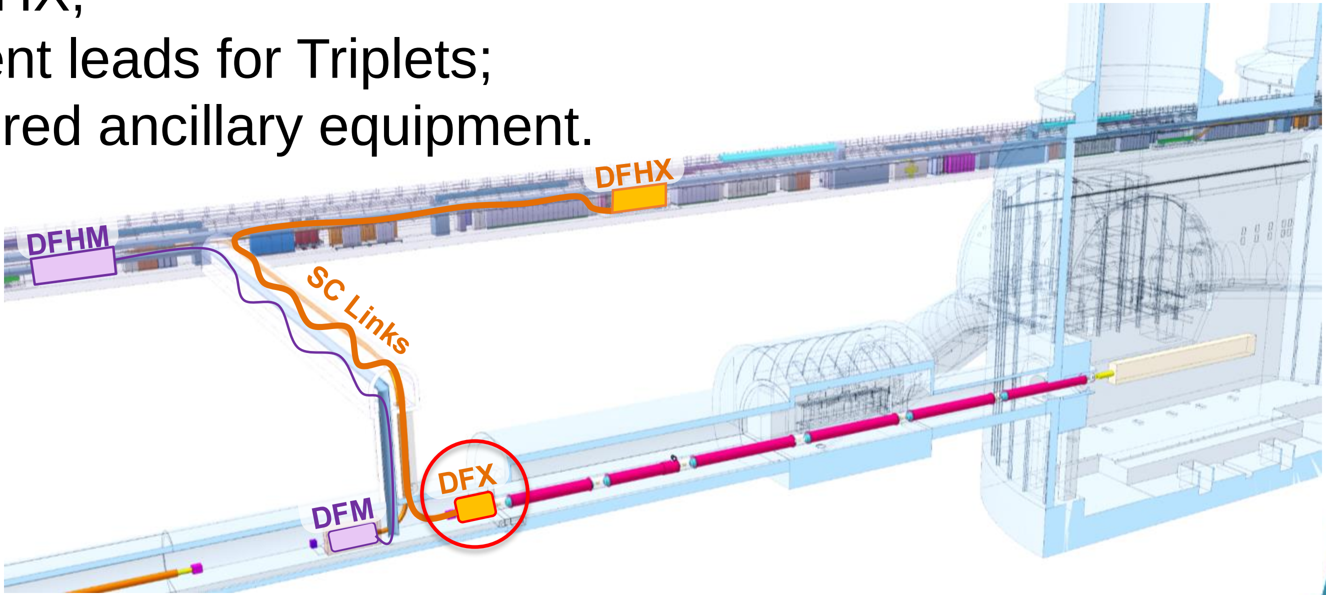


HL-LHC WP6a

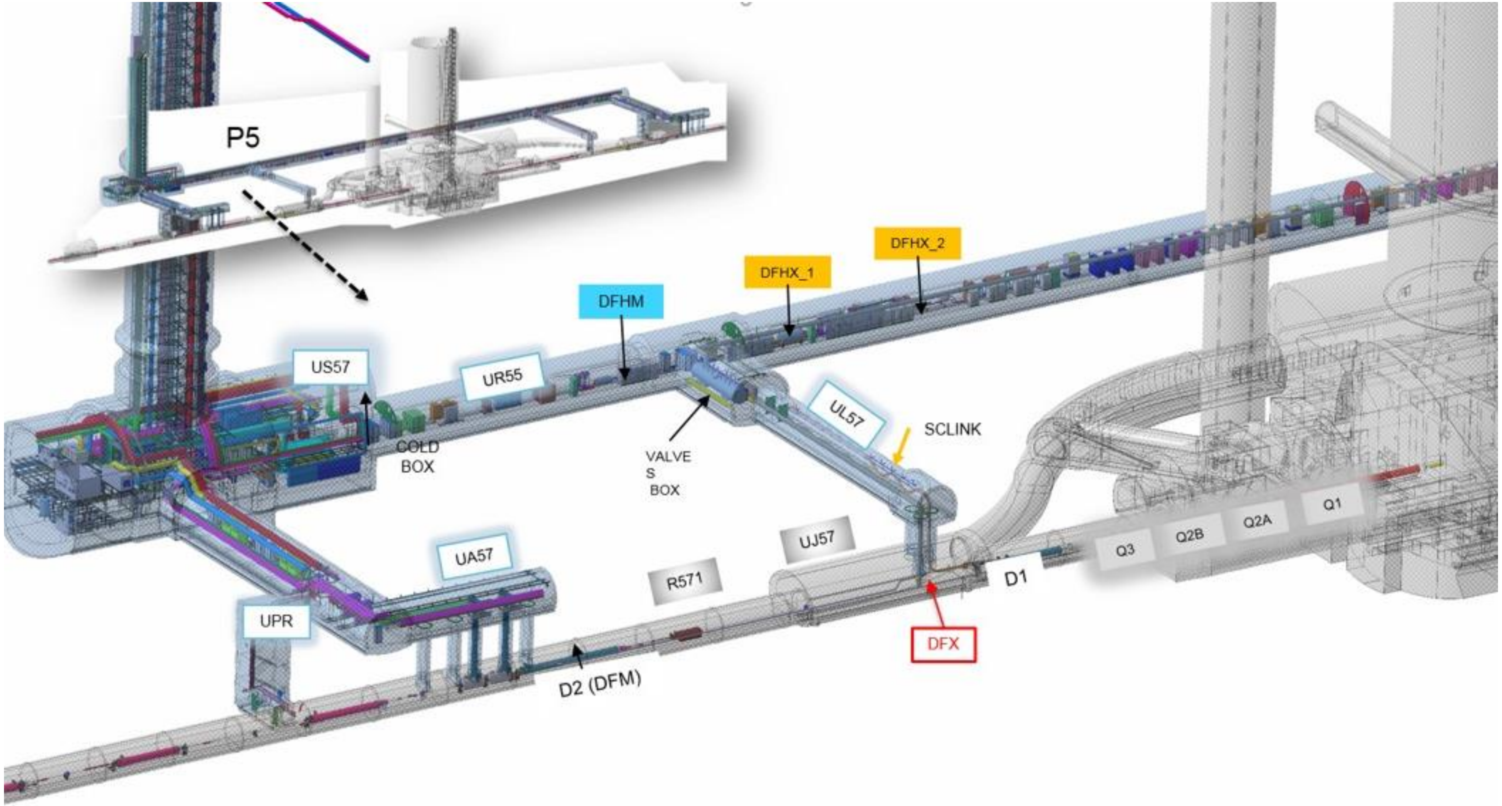
The HL-LHC Cold Powering (WP6a)

Cold powering system for HL-LHC Triplets:

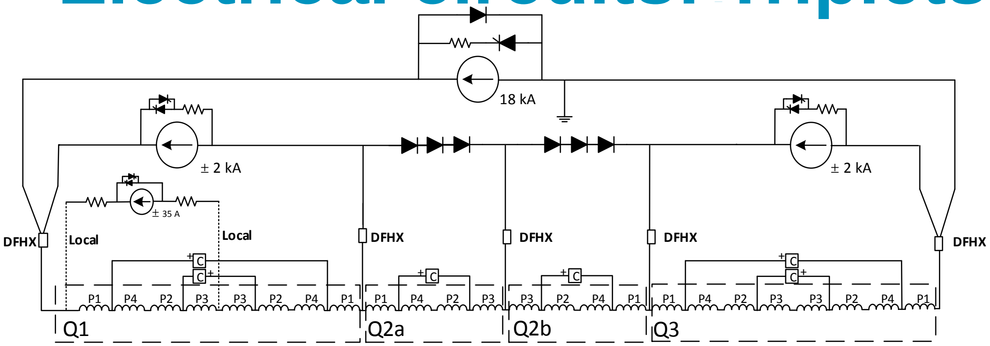
- One SC Link;
- One **DFX**;
- One DFHX;
- All current leads for Triplets;
- All required ancillary equipment.



The HL-LHC Cold Powering System



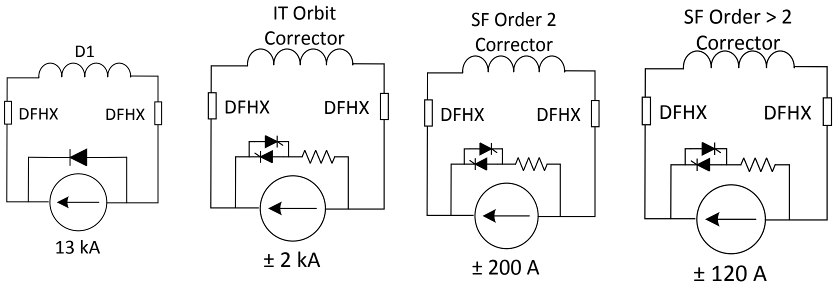
Electrical circuits: Triplets



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			
	I_{ult}(kA)	I_{peak}(kA)	I_{lead} (kA)	I_{cable}(kA)	N_{leads}/N_{cables}
MQXF	17.82	-	18	18	2
Trim Q1	2	2.4	2*	7	1
Q2a/Q2b	Protec.	5.6	2*	7	1
Trim Q3	2	6.8	2*	7	1
MCBXFB	1.73	-	2	2	2+2
MCBXFB	1.59	-	2	2	2+2
MCBXFA	1.73	-	2	2	2
MCBXFA	1.59	-	2	2	2
D1	12.96	-	18	18	2

4× 18 kA
3× 7 kA
12 × 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)

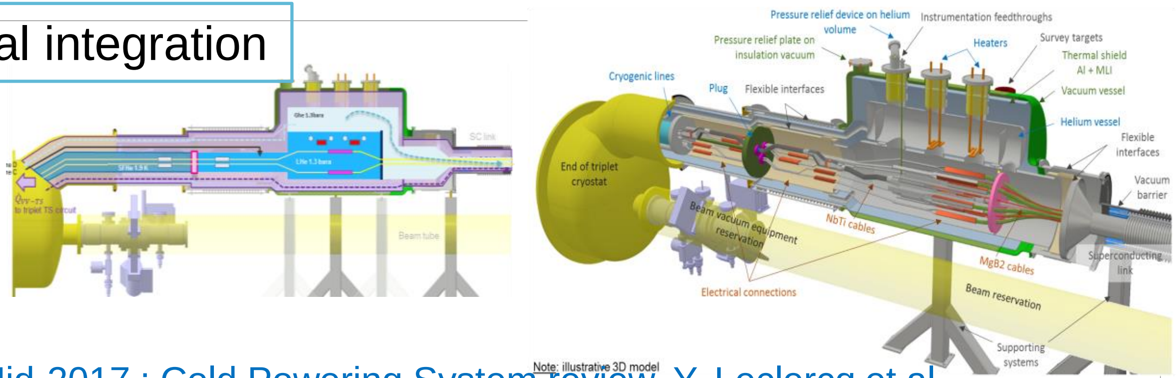
None of the above interventions requires opening the DFX. They require standard procedures and tooling. ALARA to be respected

- **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 MgB_2 to Nb-Ti splices. Also, **replacement** of **λ-plate** shall be possible. ALARA to be respected

DFX Design Evolution

DFX Design Evolution

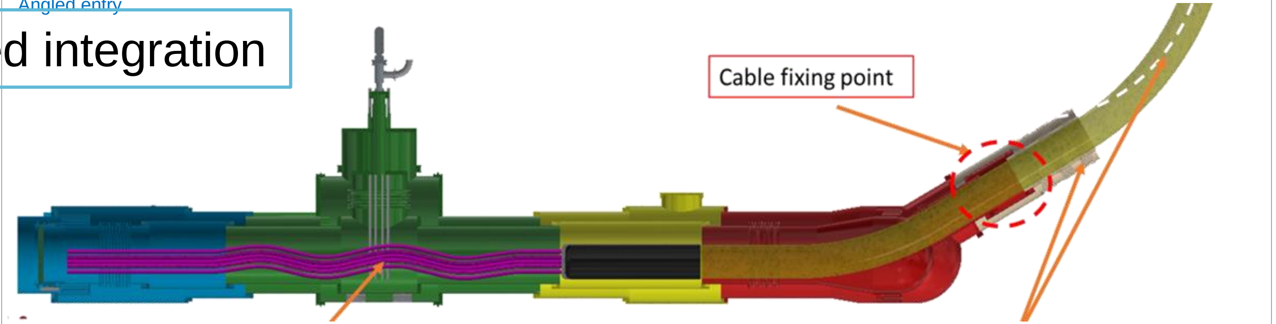
Horizontal integration



Mid-2017 : Cold Powering System review, Y. Leclercq et al

Angled entry

Inclined integration

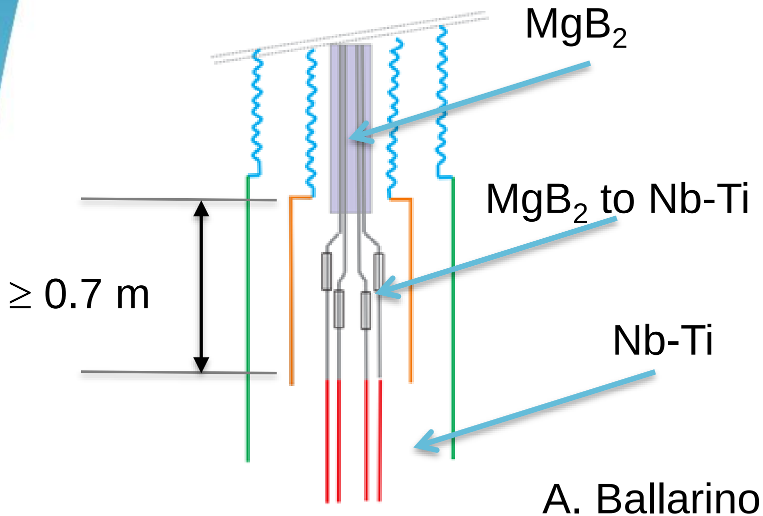


SOTON presentation July 2018, Y. Yang and W.Bailey

In both cases, MgB_2 to Nb-Ti splices done in the tunnel inside the DFX

DFX Interface to SC Link – Design Evolution

Incorporation at the cold of the SC Link of an *ad-hoc* designed **termination containing the MgB_2 to Nb-Ti splices**



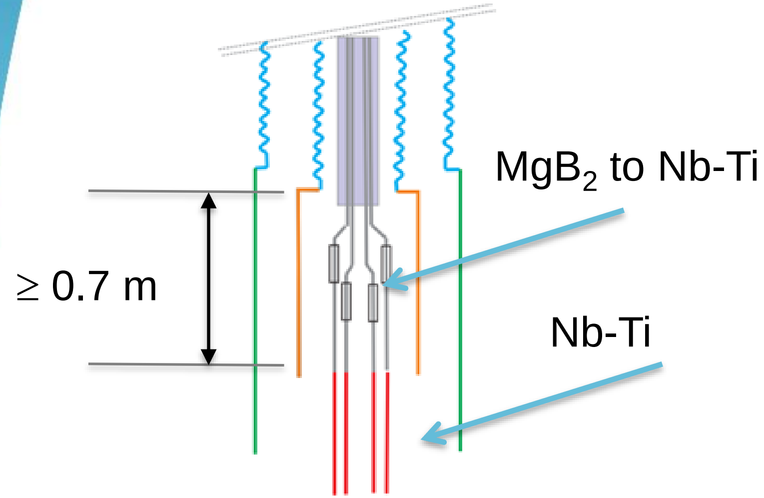
Main advantages:

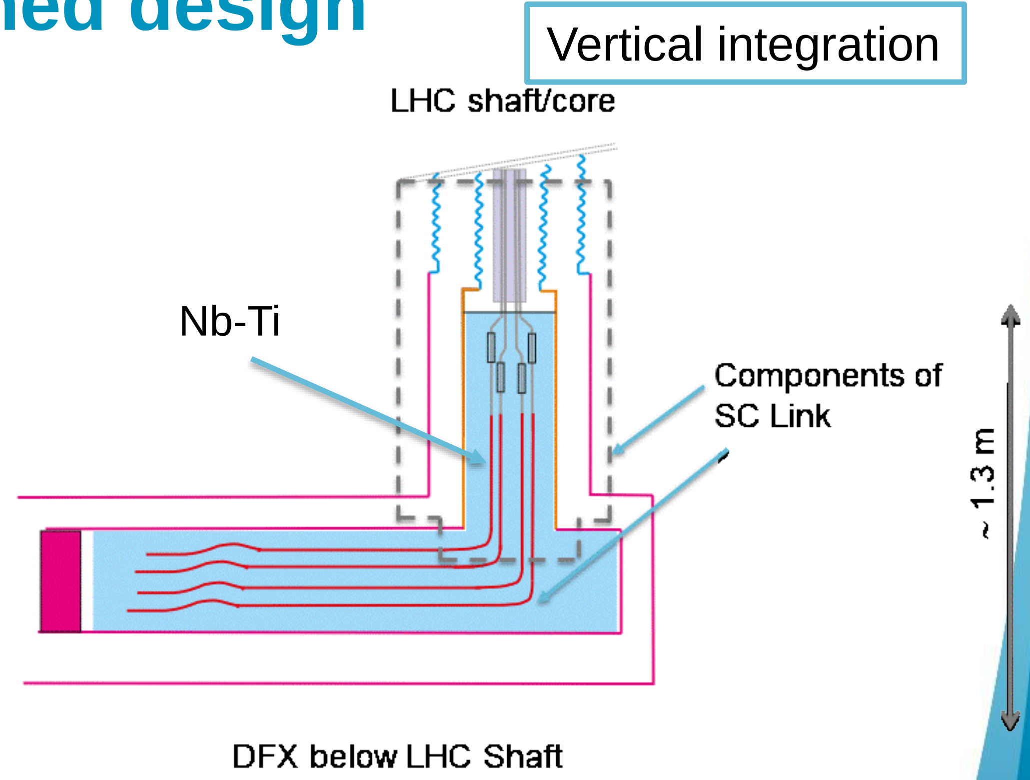
- MgB_2 to Nb-Ti splices done in the lab and incorporated in the SC link (not part of the DFX anymore);
- MgB_2 to Nb-Ti splices tested and qualified with the link before installation in the tunnel

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 MgB**2** to Nb-Ti splices; **violet** envelope = MgB_2 cable assembly; **grey envelope** = MgB_2 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 MgB_2 cables are opened and connected to Nb-Ti cables).The maximum external diameter is about 220 mm.

Retained design





Main advantage: bending and manipulation in the tunnel only of Nb-Ti cables

Retained design

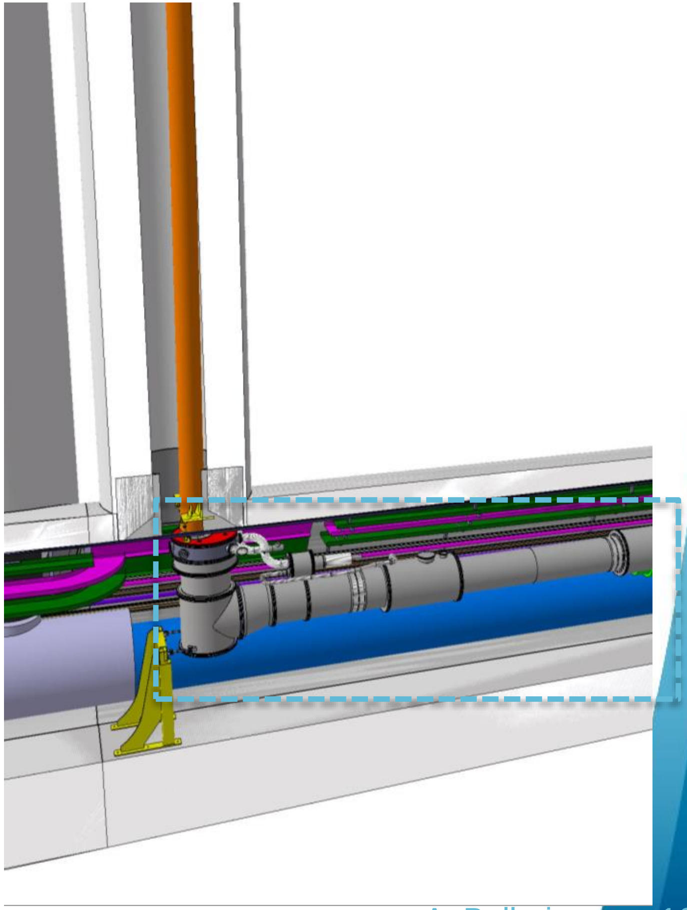
SC Link cryostat

MgB$_2$ to Nb-Ti Splices

Mock-up in preparation

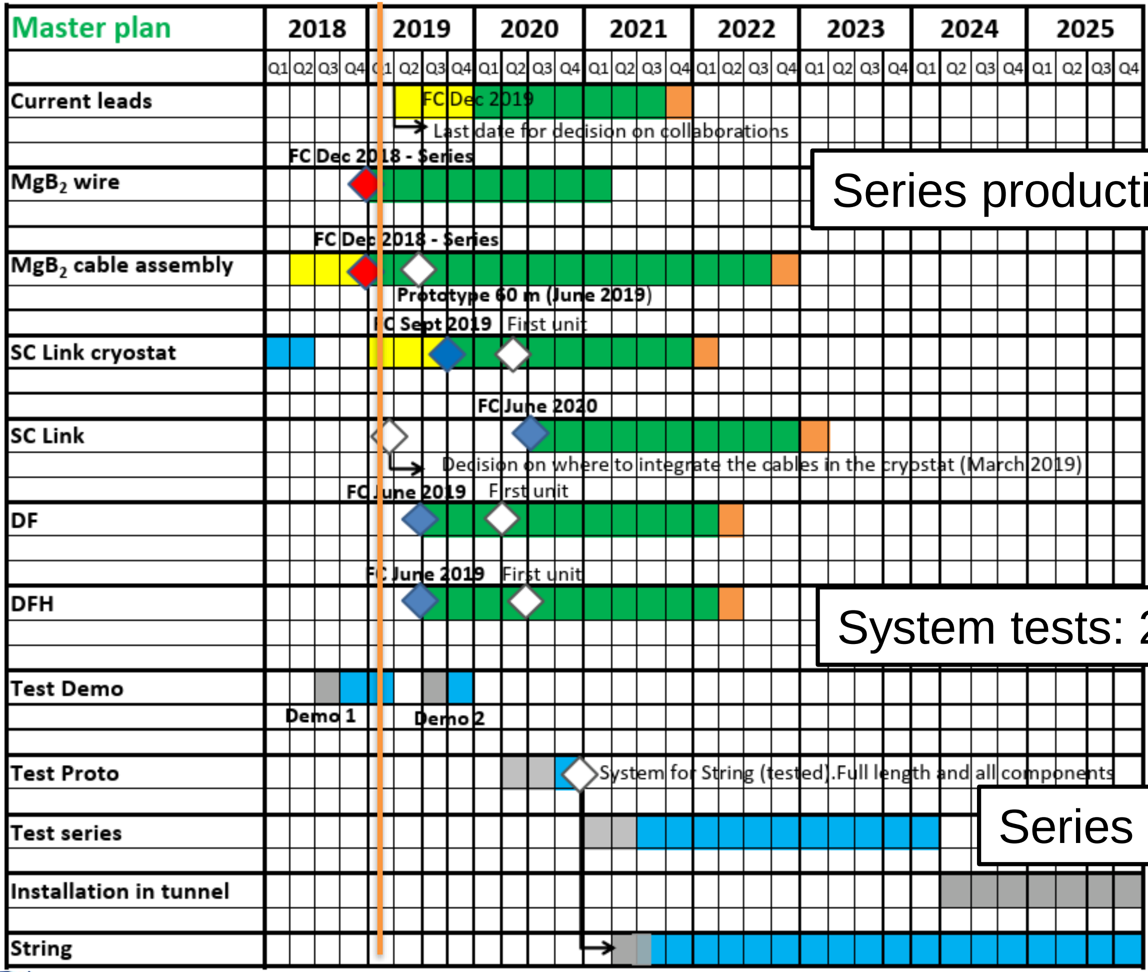
Nb-Ti flexible termination

SC Link Cryostat Interface to DFX



WP6a Schedule and key milestones

WP6a Master Plan



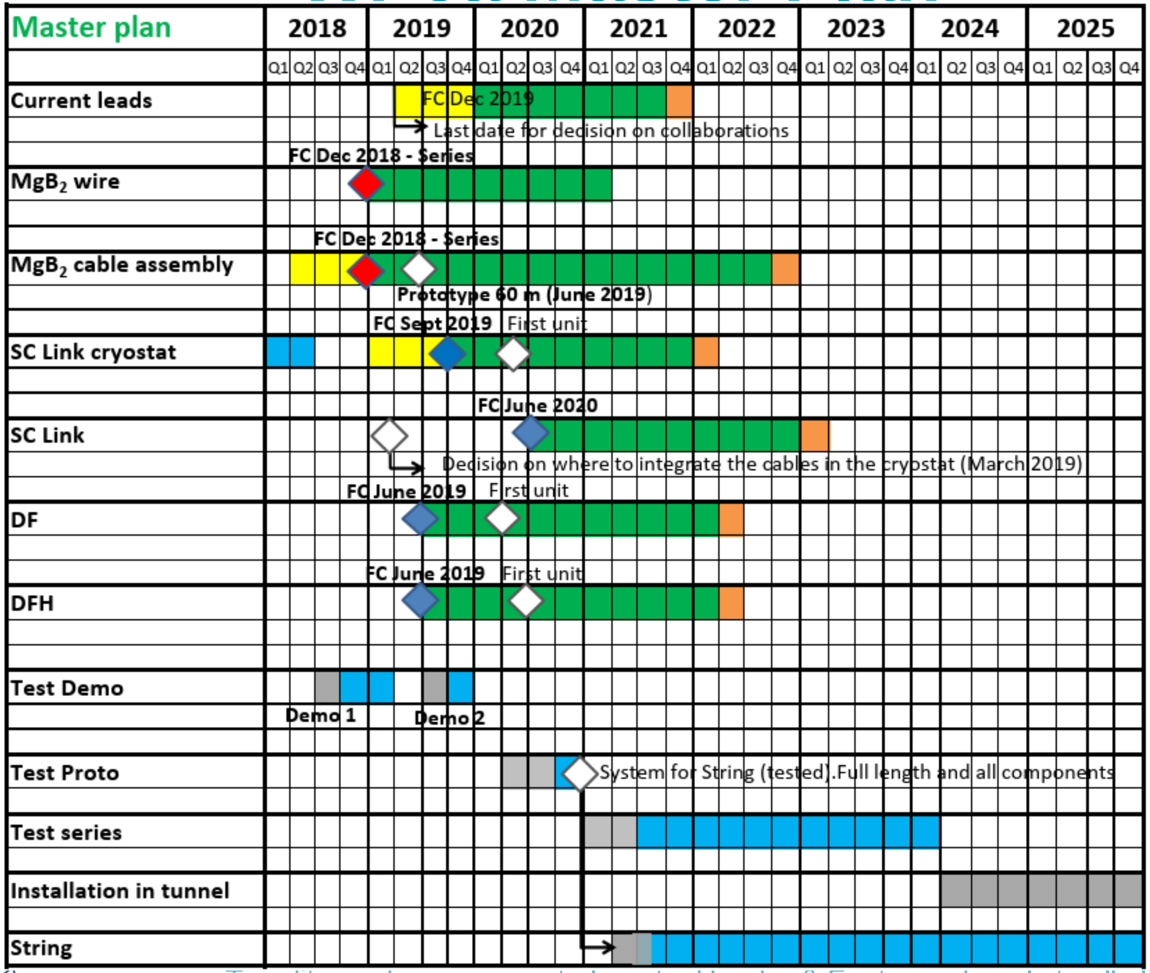
Tendering
Manufacturing
Tests
Installation
Spares
Achieved milestone
Future milestone
FC dates

Series production: 2019-2023

System tests: 2018-2020

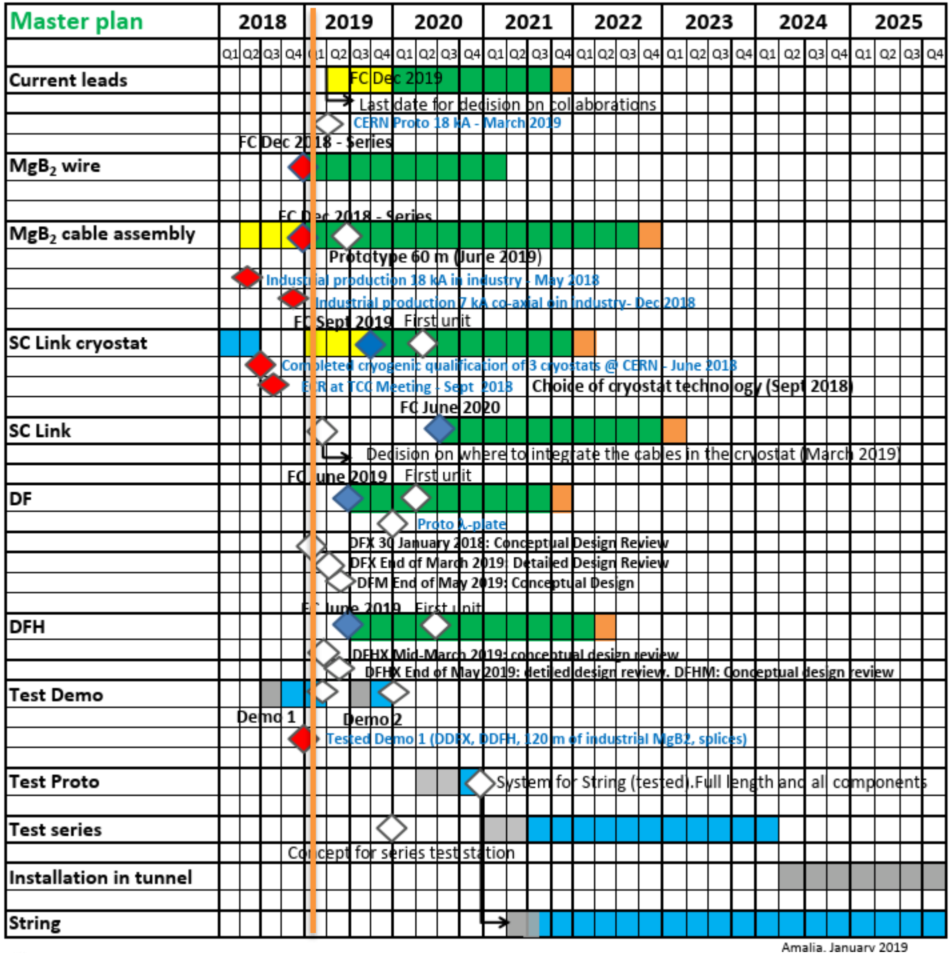
Series tests: 2021- 2023

WP6a Master Plan



WP6a Key Milestones

- Tendering
- Manufacturing
- Tests
- Installation
- Spares
- Achieved milestone
- Future milestone
- FC dates



Series procurement MgB_2– FC **Dec 2018**

Series Cabling MgB_2 – FC **Dec 2018**

SC Link Cryostat (2-walls) – **Sept 2018**

Series SC Link Cryostat – FC Sept 2019

Series SC Link assembly– FC Sept 2019

Prototype DFH – June 2020
Series DFH – FC June 2019

Demo 1 – **Dec. 2018**/ March 2019

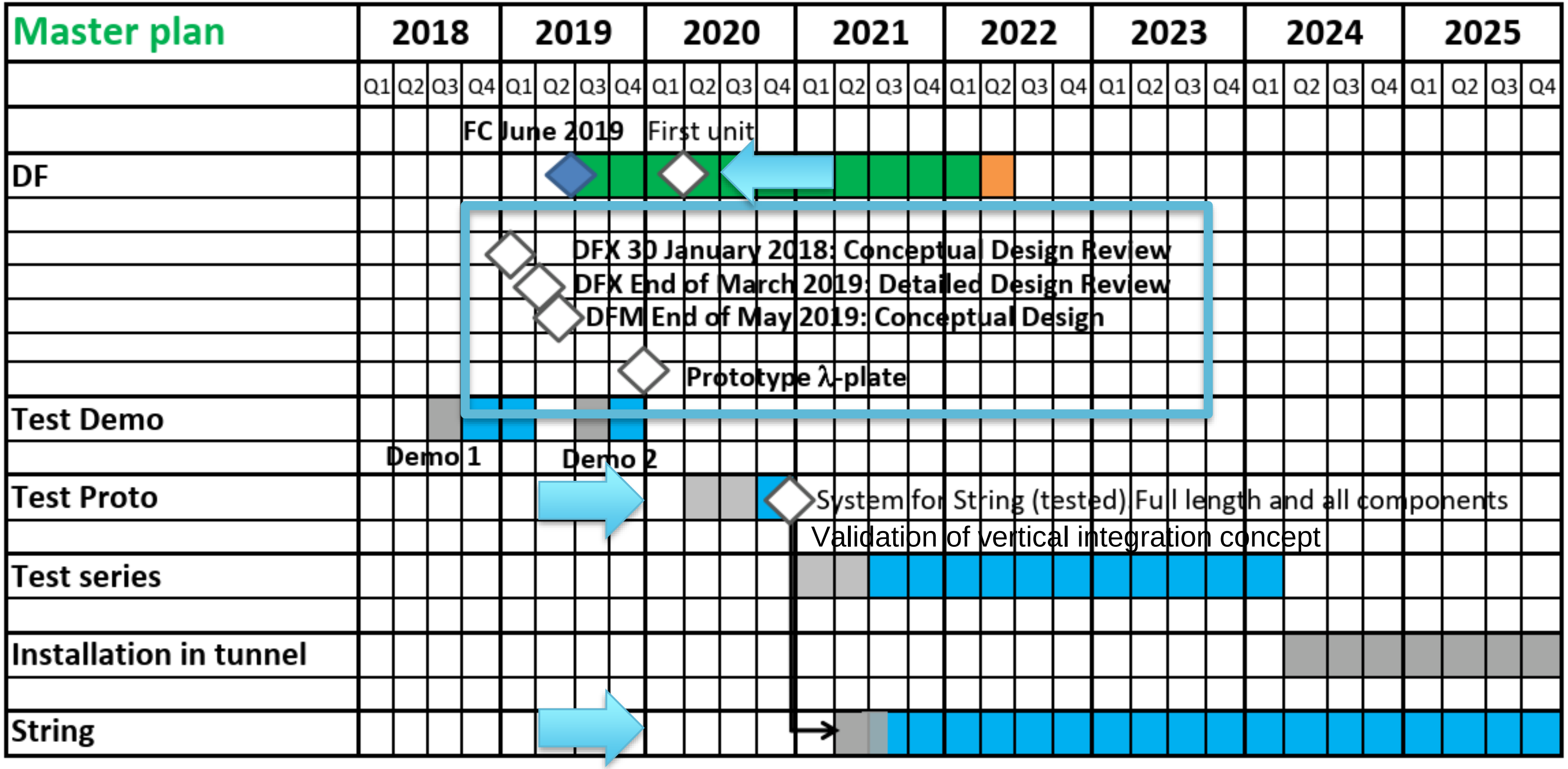
Demo 2 – Dec. 2019

Prototype System – Dec. 2020

Series Test – June 2021

String – June 2021

DFX in WP6a Master Plan



Proto: full scale system with all components – including DFX

String: full scale system with all components – including DFX

DFX Prototype – UK Collaboration

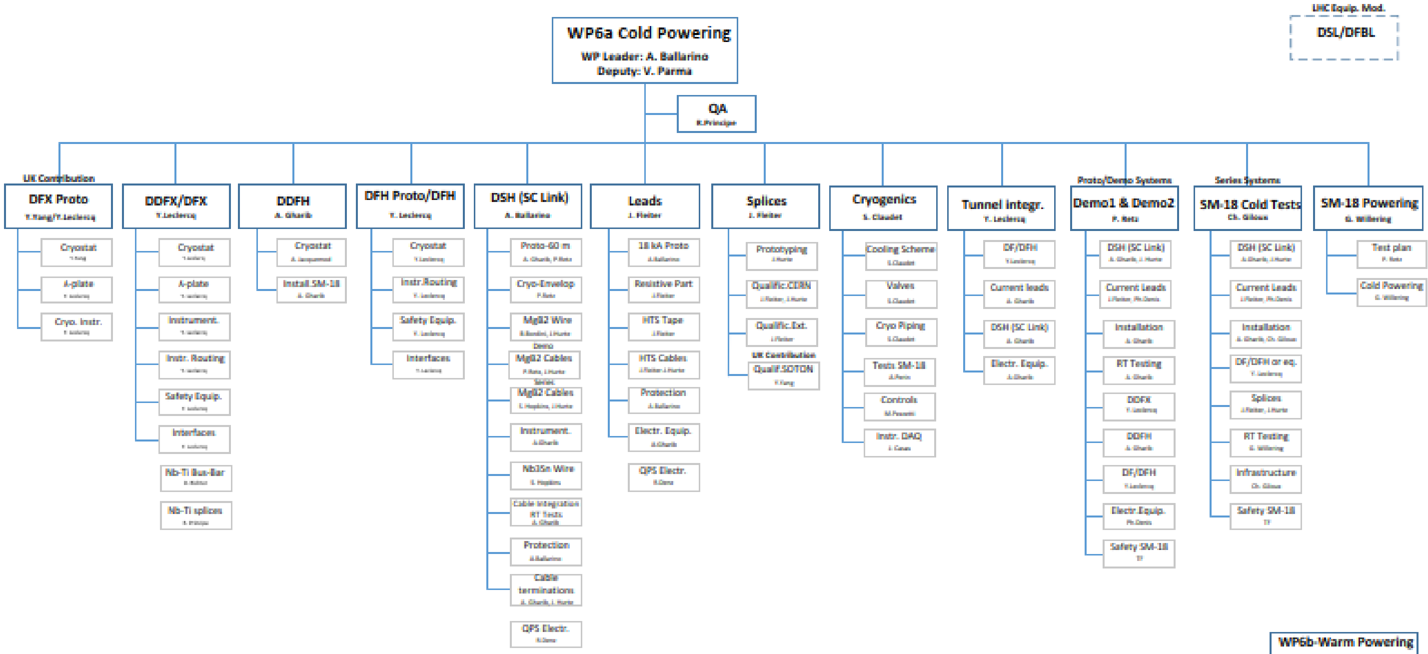
- The DFX design is being performed in the framework of the **HL-LHC UK collaboration**
- The design work is done by the colleagues at the **Univ. of Southampton** in close contact with WP6a – weekly meetings and discussions – and WP15 (tunnel integration/accessibility aspects taken into account from 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 Leads	Wire&Cables Splices	HTS Leads	Systems test	DFX DFH

WP6b-Warm Powering
M. Martino, S. Yammine

WP3-Magnets
E.Todesco

WP7-Mach.Protection
D. Wollmann

WP15-Integration
P. Fessia

WP12-Vacuum

WP16-String

WP9-Cryogenics
S. Claudet

A. Ballarino, last updated: October 2018