



## **CDR of the DFH Cryostat - WP6a**

# **Design development & preliminary production schedule**

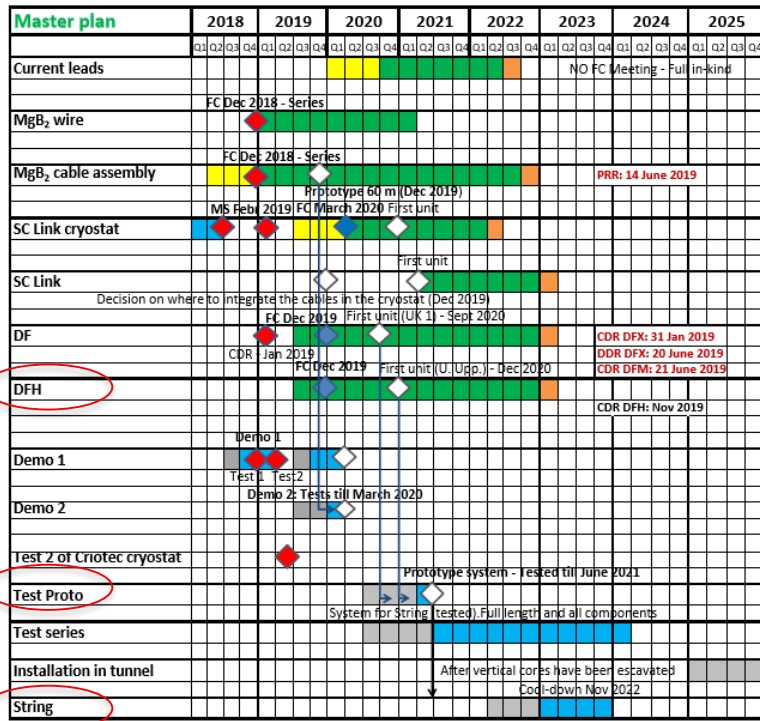
Paul Cruikshank

15 November 2019 - CERN

# Contents

- Milestones
  - DFHx #1 and DFH series
- Design Development
  - Status, next steps, resources
- Cryostat Production
  - Manufacturing & assembly approach
  - Possible preparations
- Summary

## WP6a global planning



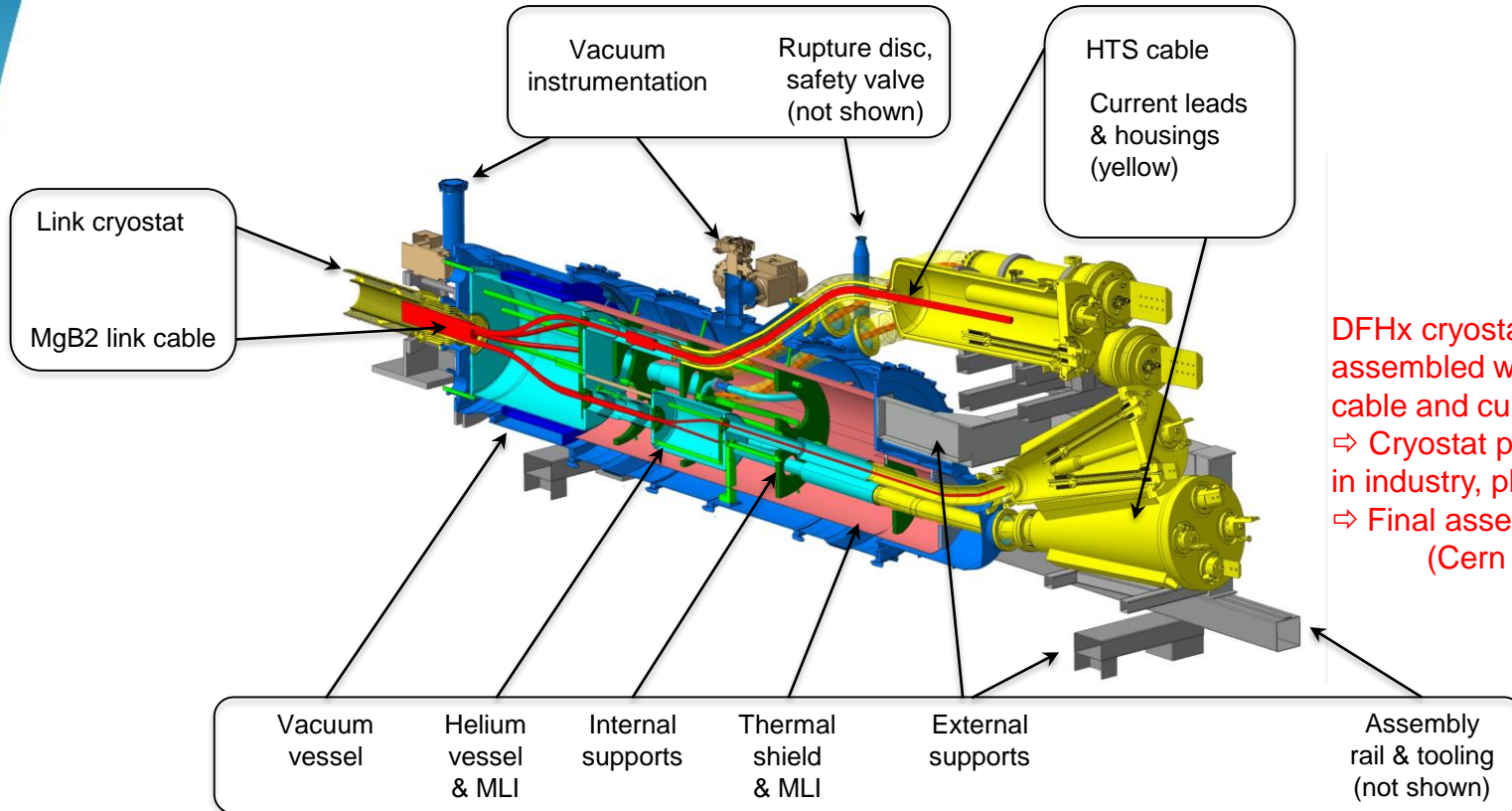
Green: manufacturing  
 Blue: tests  
 Yellow: tendering (from spec to adjudication of contract)  
 Gray: installation  
 Orange: spares

## Milestones – DFHx #1

- DFH – Manufacture DFHx #1 2020
- Test Proto – assemble & cold test DFHx with current leads, 100m SC link & DFX in standalone configuration in SM18. 2021
- String – (re)assemble\* & cold test (as above) as cold powering system to HL Triplet String in SM18. 2022-2023
- Spare - Operational spare with SC link attached (DFX proto removed). 2024

\*will be possible to keep DFH & SC link attached after the 'Test Proto'.

# DFHx sub-components



DFHx cryostat cannot be fully assembled without the MgB2 cable and current leads:  
⇒ Cryostat partially assembled in industry, plus components.  
⇒ Final assembly & test at Cern (Cern responsibility)

Uppsala Collaboration

# Milestones – DFHx & DFHm

Dates coherent with WP6a global planning

	2019	2020				2021				2022				2023					
	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4		
DFHx #1	Design development	Cryostat Manufacturing (Upp)				Assy Cern	ProtoTest					String Assembly		String Test					
DFx #1	Detail drg	Cryostat Manufacturing (SOTON)																	
DSHx #1	MgB2 cable & Link Cryostat Manufacturing																		
DFHm #1,2,3,4,5		Design development					Series OK			#1	#2	#3	#4	#5					
DFHx #2,3,4,5							Series OK		#2	#3	#4	#5							

- Milestones are indicative – need to be confirmed within the Uppsala Collaboration Agreement
- Assembly of DFHx #1 will provide feedback for optimization of the series units
- Each series DFH is assembled and cold tested before installation in the LHC tunnel.
- The margin between the Proto Test and String Test brings contingency for the former, but planning slippage would influence the DFH series production and testing

# DFHx Design Development

Today	Design phase 1	Design phase 2
CDR ✓	Tech* & Interface spec,	DDR,
3D model ✓	Instrumentation PIDs, ✓	Manu 2D drgs,
3D mock-up ✓	Integration studies,	Safety file*,
Func spec ✓	<b>PED calcs* &amp; 3D iteration,</b>	<b>PED report*,</b> ☹️
Interfaces ✓	Risk analysis,	Manu/insp plan,
Integration ✗	Assembly procedure ✓	PRR (with Uppsala).

\*Compliance with:  
Cern safety rules,  
GSI-M-04 (cryo),  
PED 2014/68/EU.

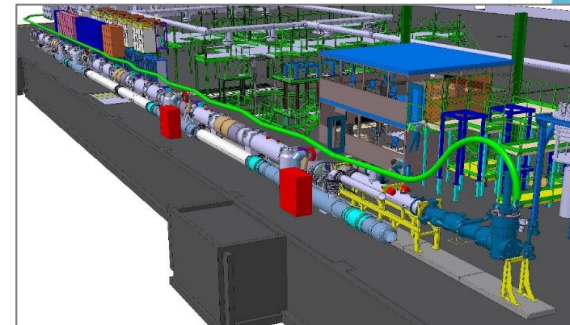
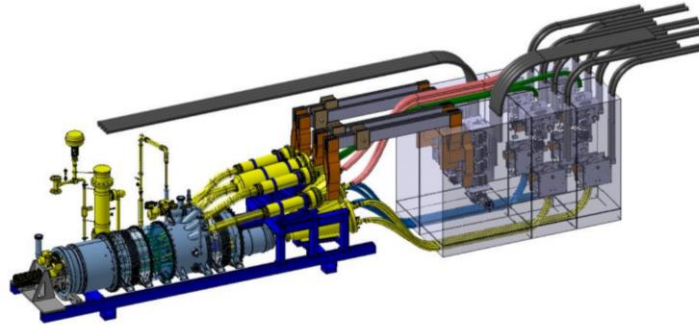
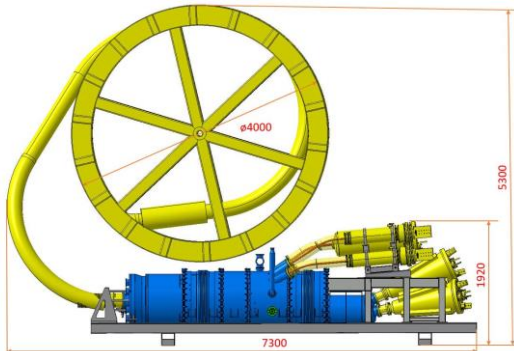
Roles:	Coordination	P. Cruikshank
	Engineering	Y. Lecercq
	Design	R. Betemps
	Integration	P. Fessia
	Transport & handling	C. Bertone
	MgB2 & HTS splices	J. Fleiter
	Warm powering	M. Martino
	Cryogenics	S. Claudet
	Quench protection	F. Rodriguez-Mateos
	Safety	V. Parma, T. Otto.

## Priorities:

- Restart DFH technical meetings in parallel with integration studies.
- Create a planning with above phases.
- Identify resources for PED analysis.
- Produce specification documents.

# Design development – DFH Integration

- A lot of work to do for integration:
  - Infrastructure - Tunnel geometry; handling, handling tooling, transport and installation routing; installation sequencing with respect to already installed infrastructure and equipment; services (EL, HVAC), access;
  - Interfaces – warm powering, machine protection, cryogenics, vacuum, controls, cabling, HVAC, metal structures, racks .....
  - Operation - preventive maintenance; removal and repair scenarios considering impact on infrastructure and other equipment,....
- Integration studies will start immediately after the CDR
- Integration solutions and the reasoning behind retained choices shall be documented.



# Design Development - DFHx

Draft 14/11/2019 v1		Nov	Nov	Dec	Dec	Dec	Jan	Jan	Jan	Jan	Feb	Feb	Feb	Feb	March	March	March	March	March	April																				
Activity	Pilot	wk 47	wk 48	wk 49	wk 50	wk 51	wk 2	wk 3	wk 4	wk 5	wk 6	wk 7	wk 8	wk 9	wk 10	wk 11	wk 12	wk 13	wk 14	wk 15																				
Integration WP6a	Paolo	[Orange shaded area]																																						
Integration DFHx	Paolo/Paul																												R											
- Warm powering	Michele																												Int											
- Cryo	Serge																												Int											
- Transport	Caterina																												Int											
- Handling	Caterina																												Int											
- EN/EL, HVAC	Paolo																												Int											
- Machine protection	Felix																											Int												
- Splice repairs	Jerome																											Int												
Mock-up trials	Jerome																					[Yellow shaded area]																		
Func Spec	Paul		V																																					
Tech Spec	Paul, Yann																																							
Interface Spec	Paul, Yann																																							
Instrumentation PID	JF,SC,FRM																																							
PED calcs	TBD																																							
3D model updates	Robin																																							
PED report	TBD																																							
DDR	WP6a																																							
Detail drawings	Robin																																							
Assy drawings	Robin																																							
Manu & insp plan	Yann & Upp																																							
Safety File	PC, VB, TO																																							
PRR	WP6a & Upp																																							
V- documents released																																								
Int - interfaces agreed																																								
R - Review																																								



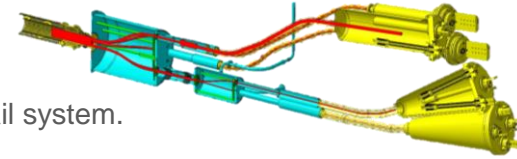
# Preparing for DFH cryostat manufacture

- Build the relationship with the Uppsala Collaboration
  - Uppsala Uni team – contacts at Fermilab, CDR, regular dialogue via teleconference (TBD)
  - Uppsala industrial partner – visits to Cern (next one 10<sup>th</sup> December), visits to Sweden (to plan).
- Formalise the Uppsala Collaboration
  - Finalise the Agreement with scope of supply, deliverables and dates (December)
  - Agree the communication lines between Cern and the Collaboration.
- Knowledge exchange with the Uppsala Collaboration
  - Identify missing competences (if any) and facilitate a dialogue with TE and EN technical groups as required eg best-practice solutions (CRG, MSC, EN-MME workshop, etc)
  - Integrate solutions from the University and industrial partner.
  - Provide opportunities for learning with Cern teams.
  - Collaboration shall contribute to the DDR.
  - Collaboration shall play a leading role in the PRR.
- Manage & share the evolution of cryostat interfaces
  - Documents and drawings for internal interfaces - current leads & SC link
  - Documents and drawing for external interfaces - handling, warm powering, cryo, instrumentation.

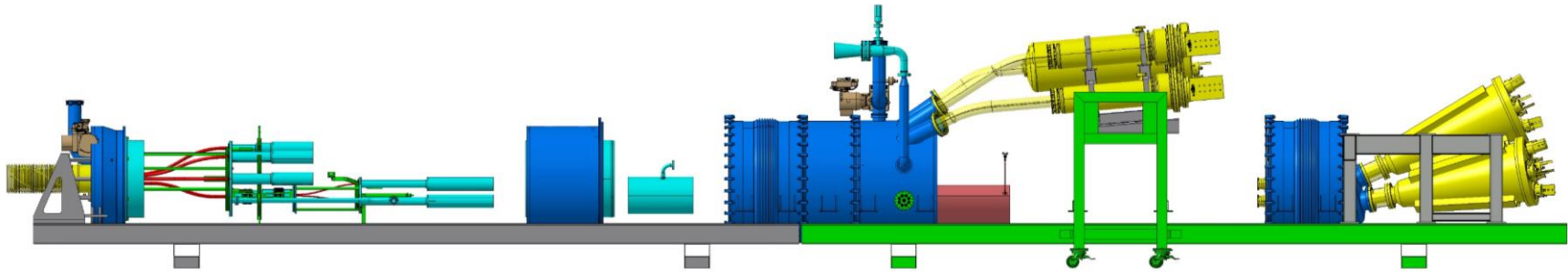
# DFHx #1 Cryostat manufacturing & assembly

	2019	2020				2021				2022				2023					
	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4		
DFHx #1	Design development	Cryostat Manufacturing (Upp)																	
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DSHx #1	MgB2 cable & Link Cryostat Manufacturing																		

- Assembly of the DFHx #1 cryostat can't be made without the DSHx link or HTS current leads
- Trial assembly of DFHx cryostat (without lip weld execution) shall be performed in industry using rail system.
- Cern may provide subcomponents for trial assembly or instrumentation for final integration.
- The methodology to ensure PED compliance of the helium pressure vessel must be agreed.
- Technology experts responsible for the DFHx assembly works at Cern (splice, welding, instrumentation, testing, etc) can provide advice on technical solutions being implemented in the production of the cryostat.
- Assembly validation at Cern provides the go-ahead for DFH series production.



⇒ Preparation of infrastructure and resources for the DFHx #1 assembly works at Cern will begin Q3 2020.



# What can Uppsala & industrial partner already do ?

- Follow the design development and provide feedback on solutions
- Review factory infrastructure needs for the manufacturing, assembly and testing area
  - Separation from incompatible co-activities, handling, etc.
- Seek potential suppliers of long lead items
  - Bellows, Forged material, MLI, others.
- Study approach to PED conformity assessment
  - Welder and welding qualification, NDT, NoBo advice, strategy for subassemblies
- Review approach to leak testing
  - Work with sub-contractor, train personnel, buy testing equipment, etc
- Review approach to cleaning
  - Facilities required, handling, training, etc.
- Evaluate if personnel can benefit from a short stay at Cern
  - Techniques: MLI, insulating supports, leak testing, cleaning, clean (HV) assembly, auto welding & cutting solutions, etc.
- Prepare the quality assurance follow-up
  - Establish contact with the Cern QA representative
  - Prepare the Manufacturing and Test Folder

# Summary

- Milestones
  - DFHx #1 and DFH series milestones are integrated into the WP6a planning
  - Delivery dates need to be finalised and included in Uppsala Collaboration agreement.
- Design Development
  - Design development is split in 2 phases.
  - An experienced Cern team is identified, however resource for PED analysis is missing.
  - The timescale can only be achievable with an intensive effort & strong availability of resources.
  - A regular technical meeting will be restarted
  - Involvement of the Collaboration in the design development can be beneficial for all parties, and will smoothen the transition to manufacturing.
- Cryostat Production
  - The DFHx #1 cannot be fully assembled in industry – but trial assembly will be performed
  - Approach for PED conformity assessment needs to be solved
  - The teams that will assemble and integrate the cables and leads at Cern can provide advice.
  - Preparation ideas for the industrial partner are listed.



***Thanks for your attention***