WP6a DFH Cryostats

DFH manufacturing & assembly options

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Recall

- DFH fundamental design change (single cryostat) - Q3 ’19
- Conceptual Design Review - Nov ‘19
- UU/RFR visit to Cern - Mid Dec ’19
- Cern brainstorming on manufacturing options - Jan ‘20

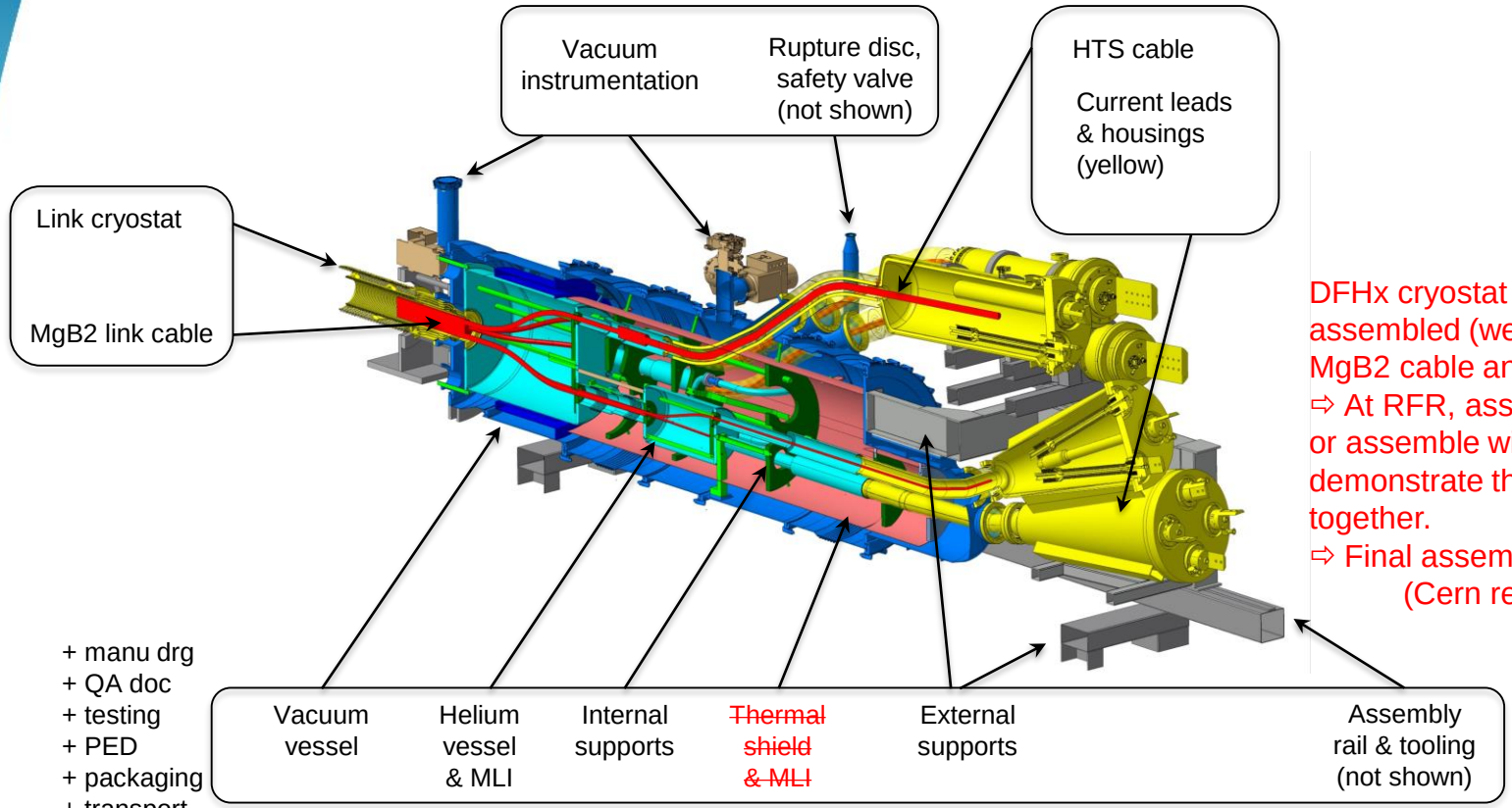
UU Collaboration with Industrial partner

- Baseline Objectives:
  - Produce 5 DFHX & 5 DFHM cryostats according to Cern design.
  - Disassemble cryostats for delivery to Cern*

- Comments
  - Unit #1 of each type will be an operational spare.
  - Supply of DFHX #1 and its subsequent re-assembly with SC cables by Cern provides the go ahead for DFH series manufacture.
  - RFR wishes to strengthen it's competencies in cryostat technologies.

*as cables of the superconducting link and HTS current leads can only be integrated at Cern, the DFH cryostats must undergo final assembly by Cern.

DFHx sub-components



Uppsala Collaboration Hardware Deliverables

DFHx cryostat cannot be fully assembled (welded) without the MgB2 cable and current leads:
⇨ At RFR, assemble & cut welds or assemble without welding & demonstrate that parts fit together.
⇨ Final assembly & test at Cern (Cern responsibility)

Uppsala & RFR visit 10/12/2019

- Cern design development according to Nov‘19 CDR plan
  - 3D design + integration by end Jan ✓
  - Calculations + detail design by end March + PRR on-going
- UU & RFR cryostat production
  - RFR request 12 months manufacturing (wrt 9 month allocation in baseline)
  - Plus, need several additional wks prior to RFR manufacture start
    - RFR review of design dossier
    - RFR make price offer to UU based on Cern specification drgs
    - UU sign contract with RFR
    - UU sign collaboration agreement with Cern
- Technical
  - If DFH assembled at RFR (welding, assy, MLI, leak test, p.test, etc) it implies re-cutting prior to delivery.
  - If DFH not assembled at RFR, learning goals are difficult to achieve

DFHX #1 planning

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																

DFHX #1 baseline — manu* — assy

DFHX #1 UU/RFR inputs 10 Dec meeting — sign — 2d check — manu* — assy

end date ?

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		

- DFHX #1 delay ~ 5 months wrt to baseline
- DFHX #1 delay doesn't impact String planning
- DFHX #1 delay impacts the early testing of the DSHX link proto & current leads
- DFHX #1 delay impacts the start date for DFH series production & UU collaboration end date

manu* = manufacture, assemble, l.test, p.test, disassemble

DFH Manufacturing

- How to fit in the baseline planning ?
- How to collaborate most effectively ?

DFH Manufacturing & Assembly Options

Options	@ Sweden	@ Cern
Baseline	Components+assembly+test+disassembly	Assembly with CL & SC cables (Cern only)
Variant 1	Components+partial assembly	Assembly with CL & SC cables (Cern only)
Variant 2	Components	Assembly with CL & SC cables (Cern with UU/RFR)

DFH manu & assembly options

Approach	Advantages	Disadvantgaes
Baseline – DFH cryostat components are manufactured, fully assembled and tested by ind partner (without SC cabling), then disassembled (cut helium vessel welds) prior to delivery to cern. DFH, CL & link assembled by Cern.	Validation of mechanical assy, l.test, p. test, CE marking. Ind partner builds cryostat with KT from cern.	Deformations due to welding & cutting may hinder assy at cern. Manpower loss: p.test, l.test, CE cert, assy/dis-assy. Assy confirmation in industry doesn't consider cable integration.
Variant 1 – DFH cryostat components manufactured and partially assembled by ind. partner without full welding of helium vessel (without SC cabling), then disassembled prior to delivery to cern. DFH, CL & link assembled by Cern.	Welding/cutting eliminated. Minor assy in industry, so reduced manpower.	No l.test or p.test on helium vessel. No CE marking. Manpower loss: assy/disassy. Assy validation incomplete. KT for ind partner is limited.
Variant 2 – DFH cryostat components manufactured by ind. partner then assembled and tested at cern with simultaneous SC cable integration. DFH, CL & link assembled by Cern, UU & RFR.	Disassembly/cutting eliminated Assy considers SC cable integration. Assy execution, optimisation & issues (including reworking) resolved by cern/UU/ind partner together. Max KT opportunity for industrial partner.	Increased assembly resources required at cern.

Assemblability validation of UU/RFR supply

Approach	Validation objective	Vacuum vessel	Helium vessel	Internal supports	Assy tooling	Comments
Baseline	Cryostat assemblability	✓	✓	✓	✓	Cryostat is assembled with neither CL nor SC link so constraints during final assembly sequence at Cern are not evident
	Link & CL assemblability*	✓	✗	✗	✗	
Variant 1	Cryostat assemblability	✓	✗	✗	✗	Vacuum chamber can be assembled on external supports. Assy checks on components can be made to validate machining tolerances but assy sequence can't be performed.
	Link & CL assemblability*	✓	✗	✗	✗	
Variant 2	Cryostat assemblability	✓	✓	✓	✓	Assy sequence with link and current leads can be validated/optimised
	Link & CL assemblability*	✓	✓	✓	✓	

*mechanical interfaces to cryostat, routing of SC cables, splice execution, routing of instrumentation cabling.

DFHX #1 Knowledge Transfer Opportunities – Variant 2

KT Opportunity	Vacuum vessel	Helium vessel	Internal supports	External Supports	Multi-layer insulation	Cryostat Assembly
Material choice						
Component manu				KT@RFR		
Welding						
Cleaning						
HV assembly						
Sealing tech						
Instrumentation						
Pumping						
Leak testing			KT@RFR			
Pressure test					KT@cern	

3-4 months assembly duration,
RFR % presence/timing to be agreed,
Component delivery sets start date

Planning Optimisation

- Consider strategy for DFHX #1 ≠ DFH series
- @UU/RFR
  - Baseline scope = components+assy+test+disassy
  - Variant 2 scope = components
- @Cern
  - Baseline design change/reworking = transport Cern/RFR/Cern
  - Variant 2 design change/reworking = Cern workshops
- Comments
  - Cern design is based on Cern assembly methods & existing tooling
  - Variant 2 - RFR can built-to-print with higher confidence
  - Variant 2 - knowledge transfer easier to integrate

⇨ RFR manufacturing duration in Sweden reduced with Variant 2 ?

DFH baseline & variants summary

- Baseline
  - Provides validation of cryostat assemblability in industry with the risk that SC cable integration difficulties can be found quite late at cern, requiring reworking of the supply.
  - Manpower to assemble and test the cryostat in industry is lost due to the obligation to reopen the helium vessel.

- Variant 1
  - Provides a cost effective approach for series production with a validated solution
  - Manpower resource needs are lower in industry but higher at cern.

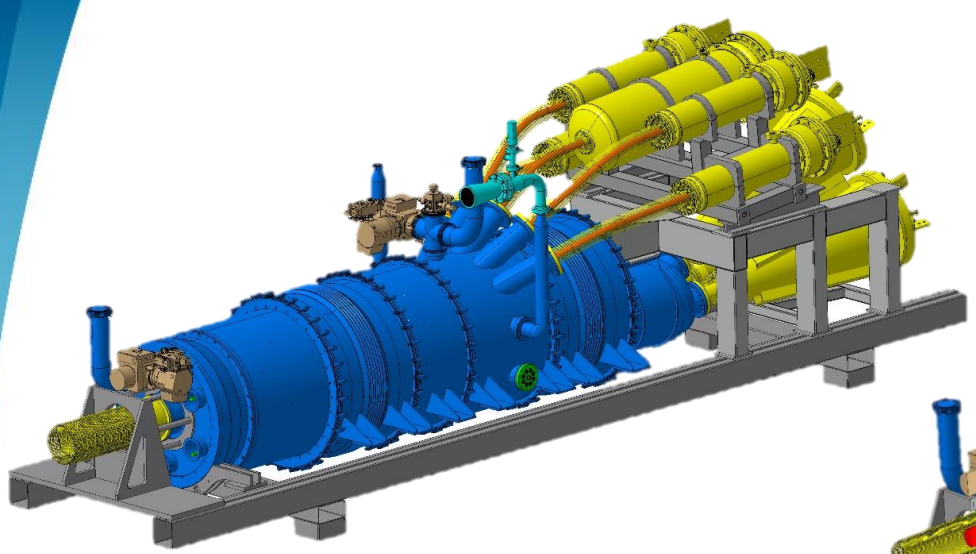
- Variant 2
  - Provides validation of cryostat assemblability, plus validation of SC link and current lead assemblatility.
  - Brings together Cern, Uppsala and RFR during the assembly phase, facilitating execution/problem solving/optimization/learning.
  - Provides an effective approach for start-of-series production eg DFHX #1 & DFHM #1.

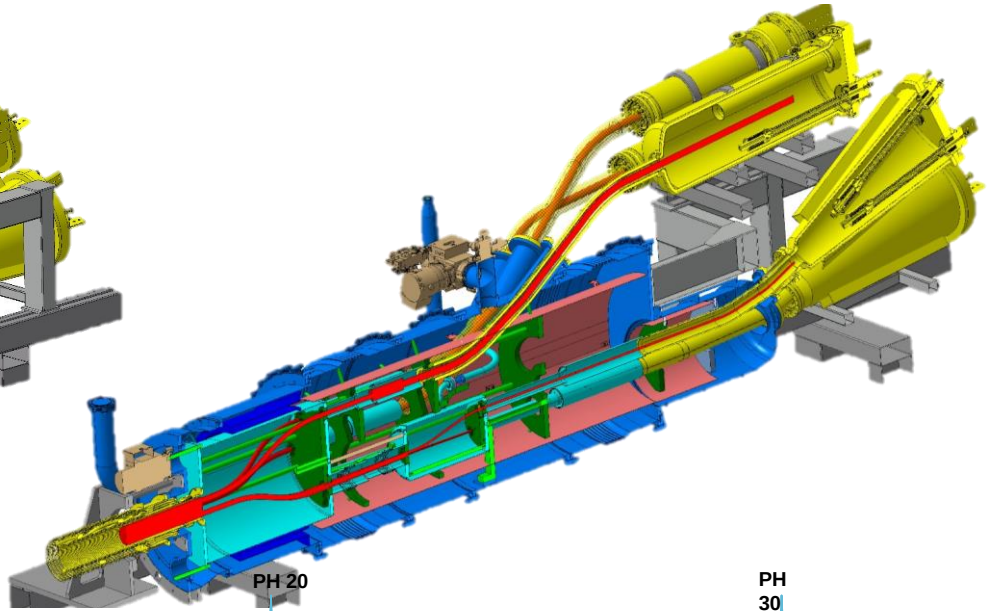
DFH proposal

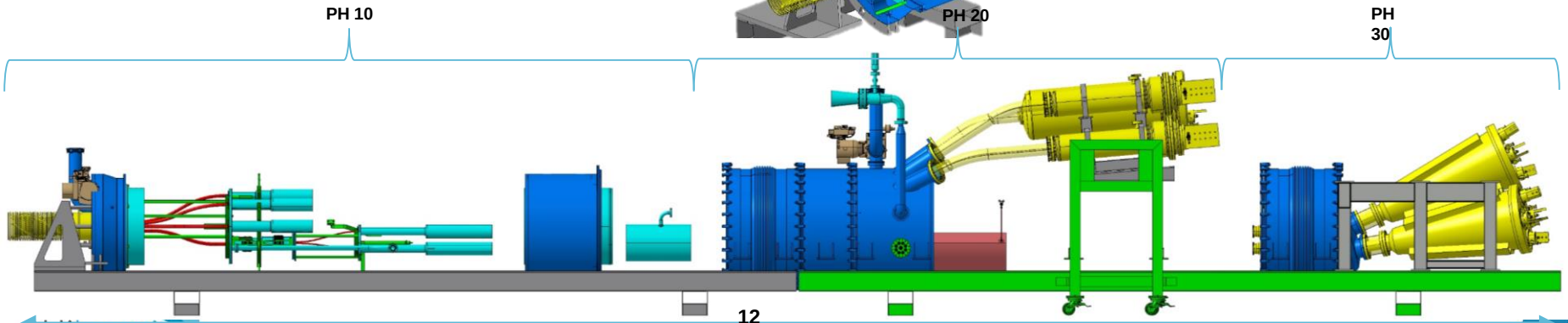
- Propose Variant 2 for production of DFHX #1 & DFHM #1
- Propose Variant 1 or Variant 2 for production of DFH series, with RFR assistance at Cern.
- Explore how UU, RFR and Cern can drive the component and assembly works, ensuring timely assembly of DFHX #1 at Cern in early 2021 (with CL and SC link),…..and providing maximum opportunities for knowledge transfer.

Thanks for your attention !

Spare Slides



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