



HL-LHC project Status @ CM #12

Oliver Brüning – CERN – Project Leader
On behalf of the HL-LHC project

Uppsala – September 19th to 22nd 2022

H I G H L U M I N O S I T Y L H C

12th HL-LHC Collaboration Meeting UPPSALA - Sweden 19 - 22 September 2022



The 12th HL-LHC Collaboration Meeting will take place in Uppsala, Sweden, from 19th to 22nd September 2022, as an in-person meeting.

Based on the traditional programme with plenary and work package parallel sessions, this meeting will serve as a technical update forum for the 6th Cost and Schedule Review, planned at CERN in November 2022, and provides the framework for additional collaborative meetings between the project partners.

This year, the main objectives will be to update all HiLumi collaborators on the results of key HL-LHC prototypes tests, to highlight the progress made in the transition from prototype validation to series production, and to update all collaborators on the latest schedule changes.



CERN - Organizing Committee Uppsala - Organizing Committee For more details and registration

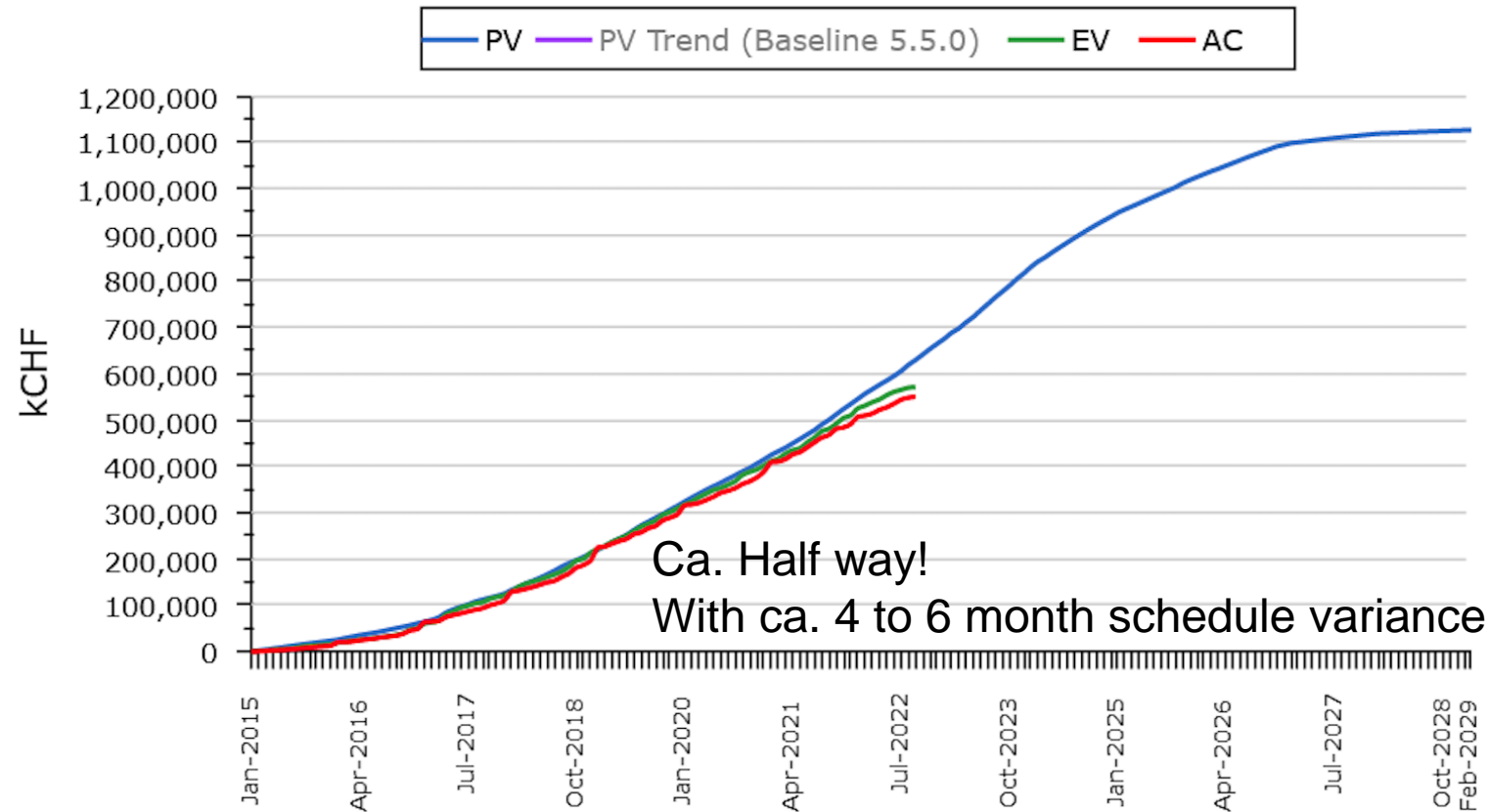
<i>Oliver Brüning</i>	<i>Project Leader</i>	<i>Tord Ekefj</i>	<i>Chairperson</i>	<i>cecile.noels@cern.ch</i>
<i>Markus Zerlauth</i>	<i>Deputy Project Leader</i>	<i>Richard Benner</i>	<i>Head of Physics Department</i>	<i>www.hilumihc.web.cern.ch</i>
<i>Cécile Noels</i>	<i>Project Office</i>	<i>Maja Olvegård</i>	<i>Head of FREIA Department</i>	
<i>Irene García Obispo</i>	<i>Project Office</i>	<i>Rocio Santiago Kern</i>	<i>Technical Leader (DHF project)</i>	



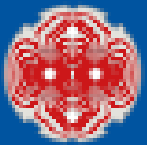
Reminder of the HL-LHC Goals

From FP7 HiLumi LHC Design Study application in 2010

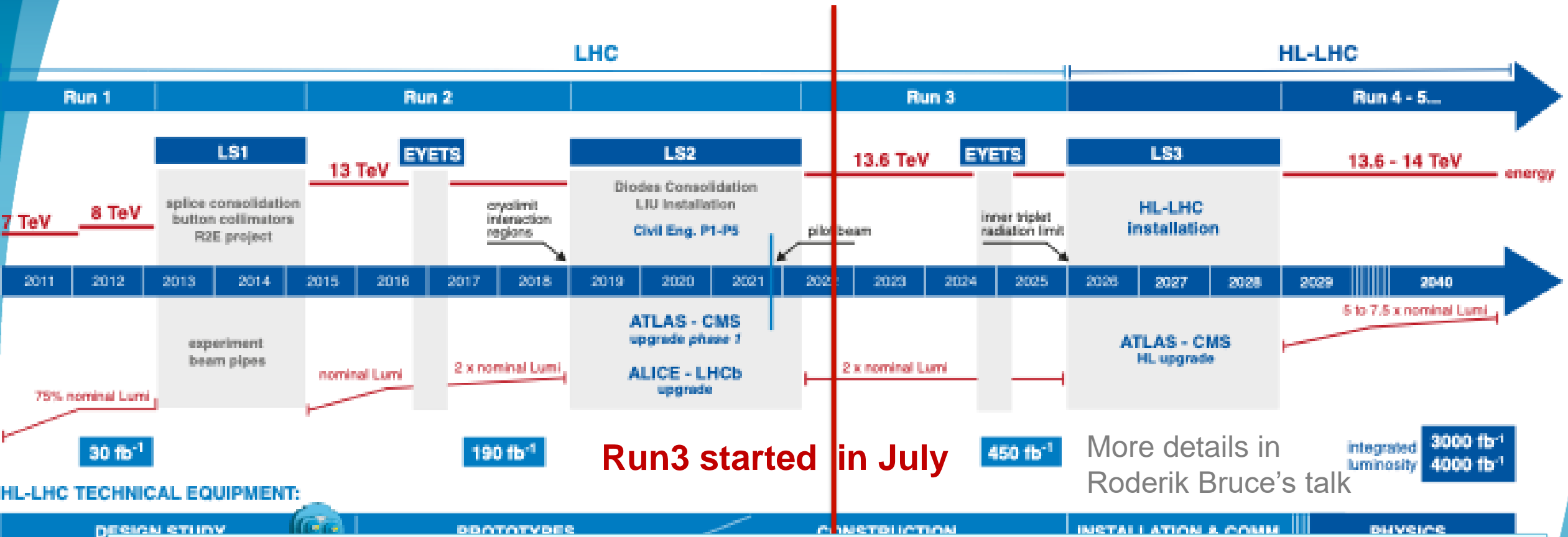
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LHC / HL-LHC Plan



Run3 started in July

More details in Roderik Bruce's talk

HL-LHC TECHNICAL EQUIPMENT:

DESIGN STUDY PROTOTYPES CONSTRUCTION INSTALLATION & COMMISSIONING PHYSICS

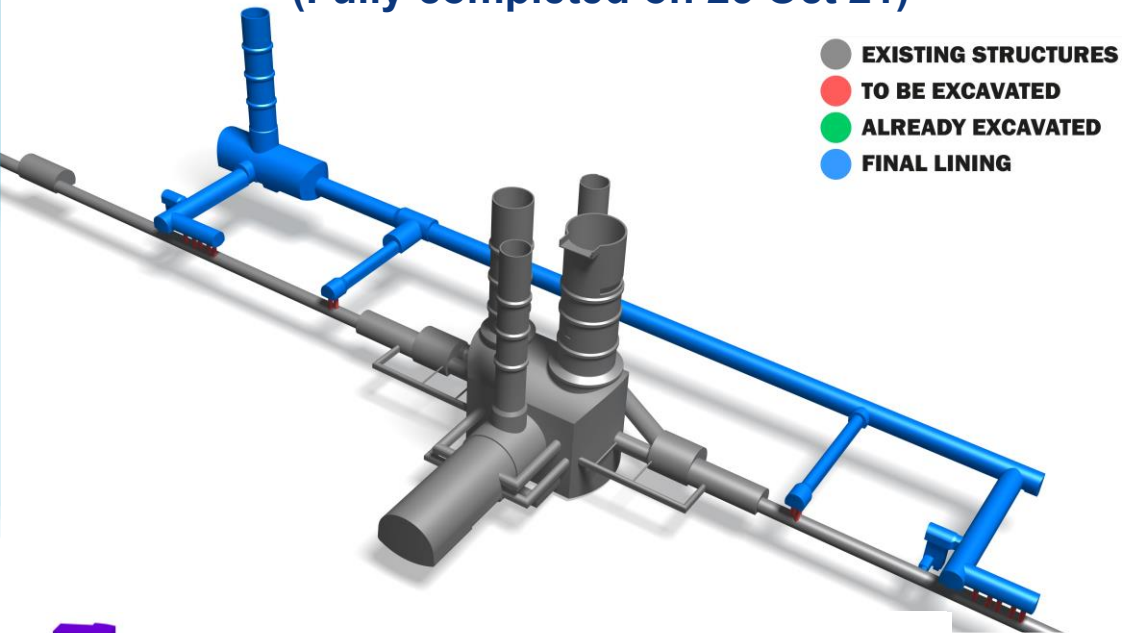
Run3 started with excellent performance
Beam Energy for Run3 fixed @ 6.8 TeV [long training time and need for repairs - RF PIM S23]
LS3 shifted by 1 year and extended to 3 years
→ HL-LHC keeps the construction schedule unchanged where possible to keep the momentum!
→ IT String operation still scheduled to start in 2024, but with main operation period in 2025



Main civil engineering work at Point 1 (ATLAS)

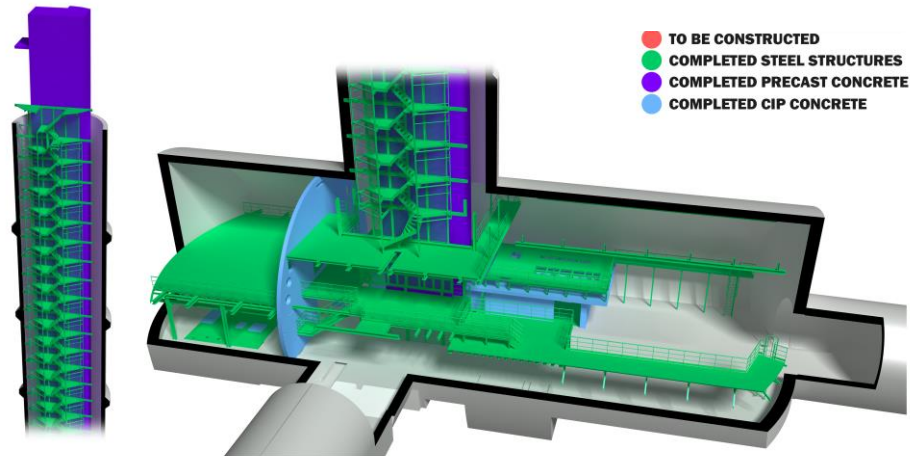
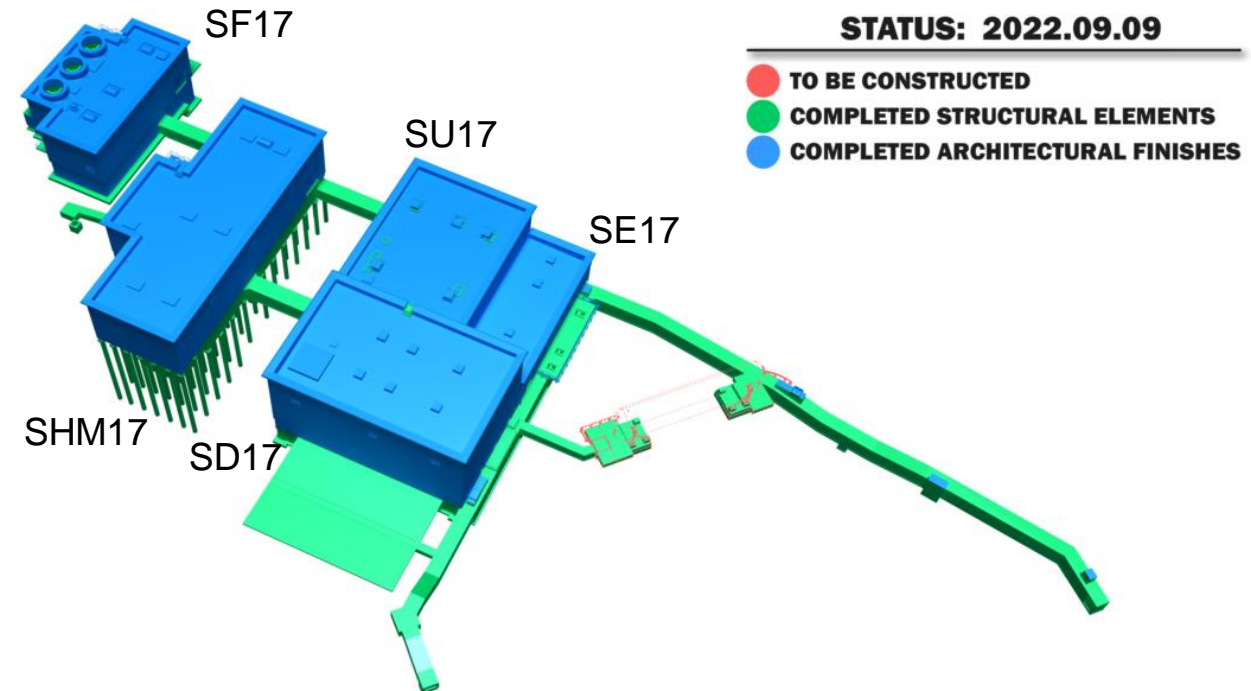
Underground

(Fully completed on 25 Oct'21)



Surface

STATUS: 2022.09.09

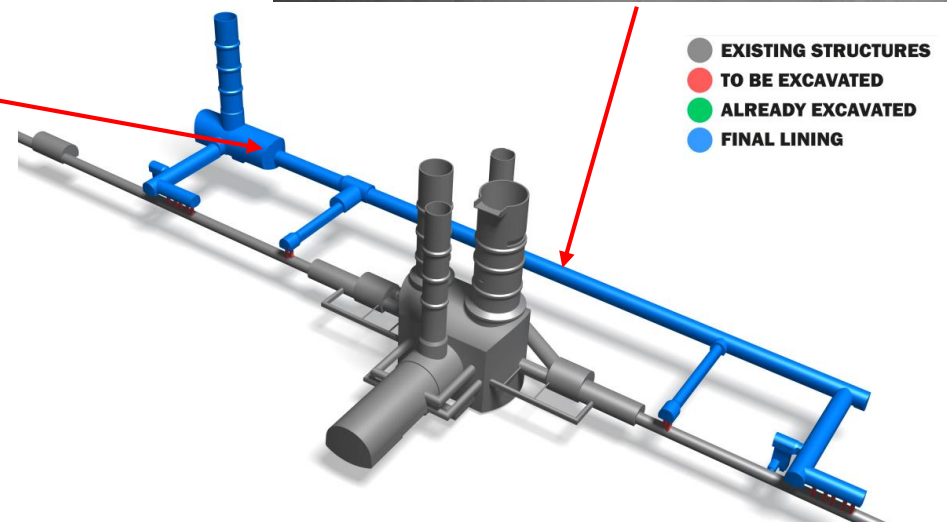


Buildings	Progress [%] / delivery
SF17	100% / delivered
SHM17	100% / delivered
SU17	100% / delivered
SE17	95 % / 26 Sep'22
SD17	95 % / 26 Sep'22
Underground	100% / 26 Sep'22

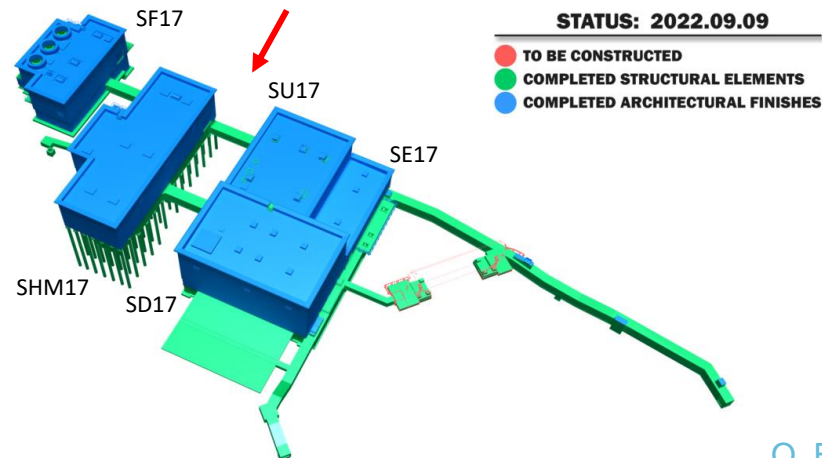
Fully completed and delivered by Sep'22 (+ ~1 months w/r to the initial contractual date)

Pieter Mattelaer and Laurent Tavian

Main civil engineering work at Point 1 (ATLAS)



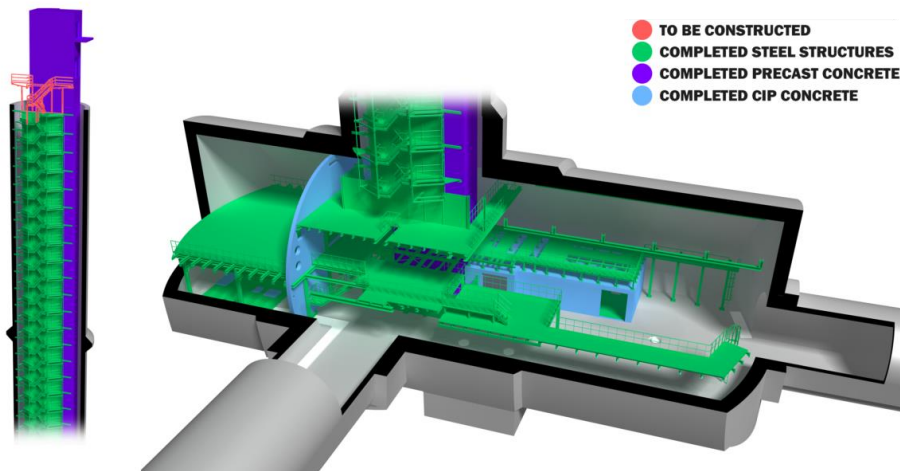
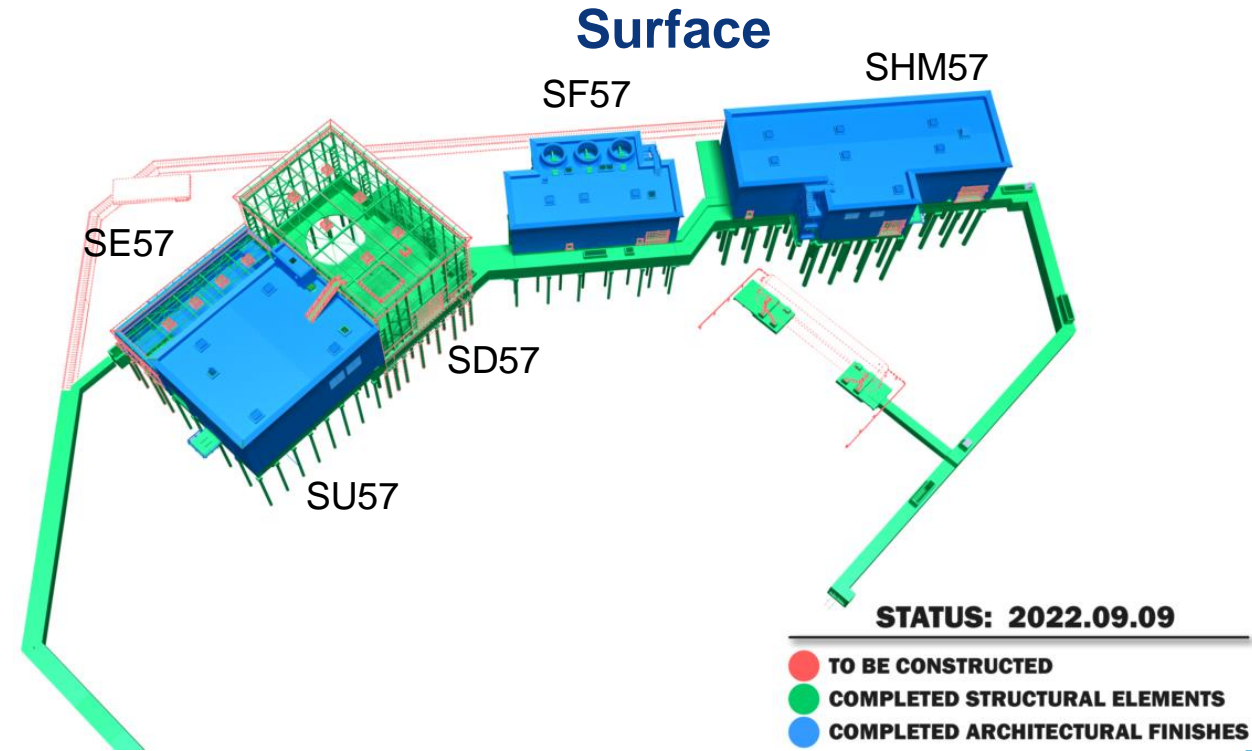
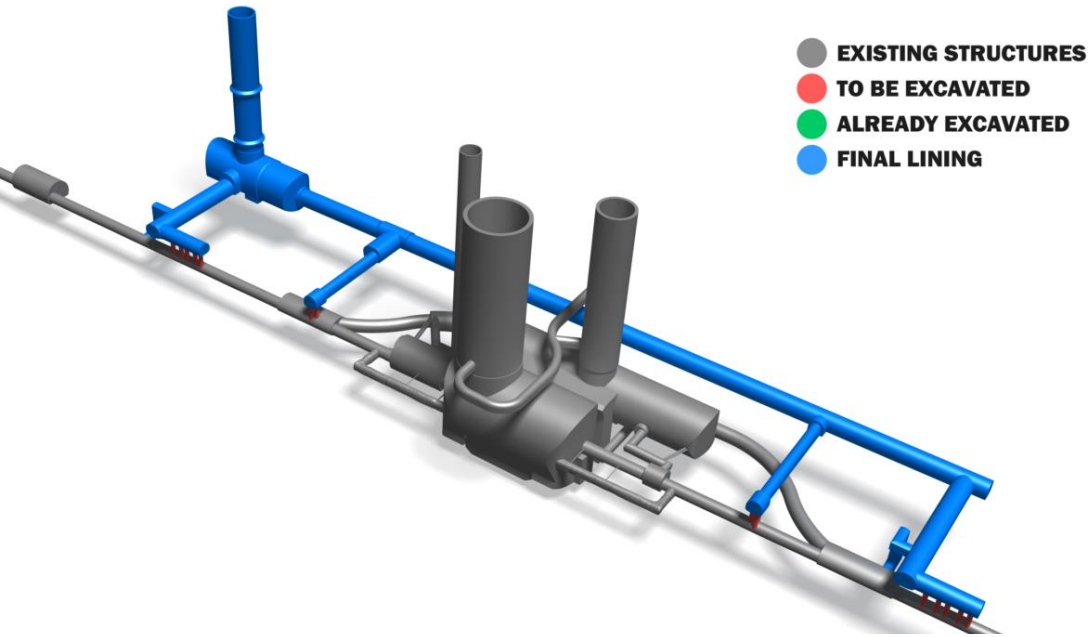
Main civil engineering work at Point 1 (ATLAS)



Pieter Mattelaer and
Laurent Tavian

Main civil engineering work at Point 5 (CMS)

Underground
(fully completed on 25 Feb'22)

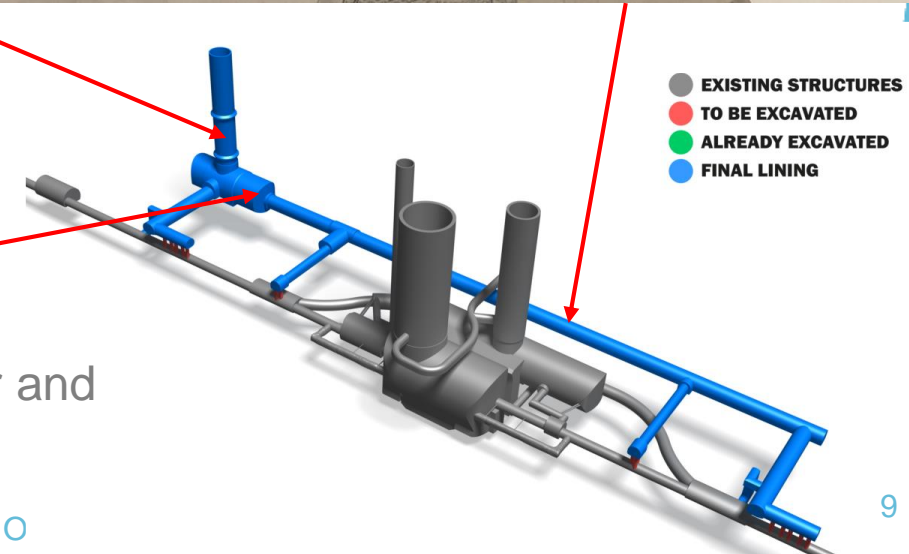
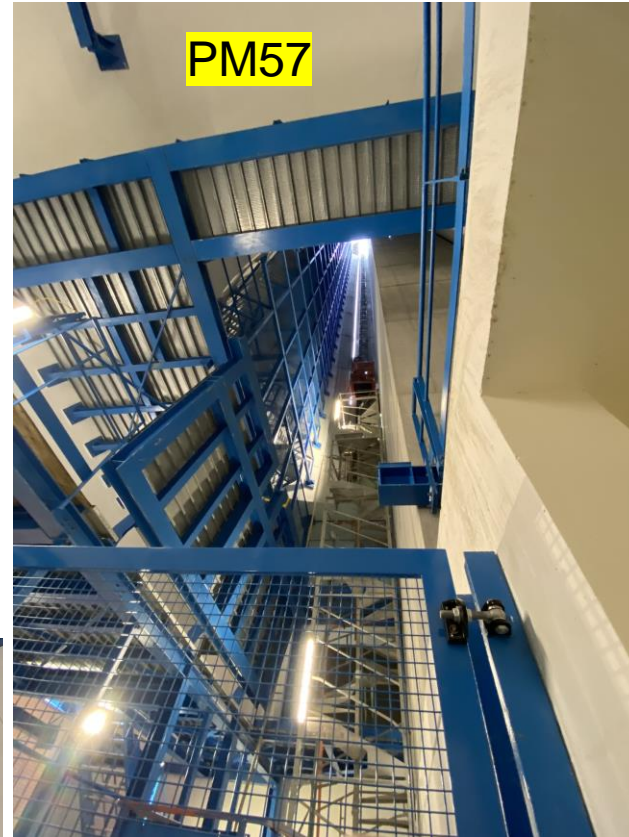


Buildings	Progress [%] / delivery
SF57	100% / delivered
SHM57	100% / delivered
SU57	100% / delivered
SE57	70 % / 01 Dec'22
SD57	60 % / 01 Dec'22
Underground	100% / 01 Dec'22

Fully completed and delivered by Dec'22 (+ ~2 months w/r to the initial contractual date)

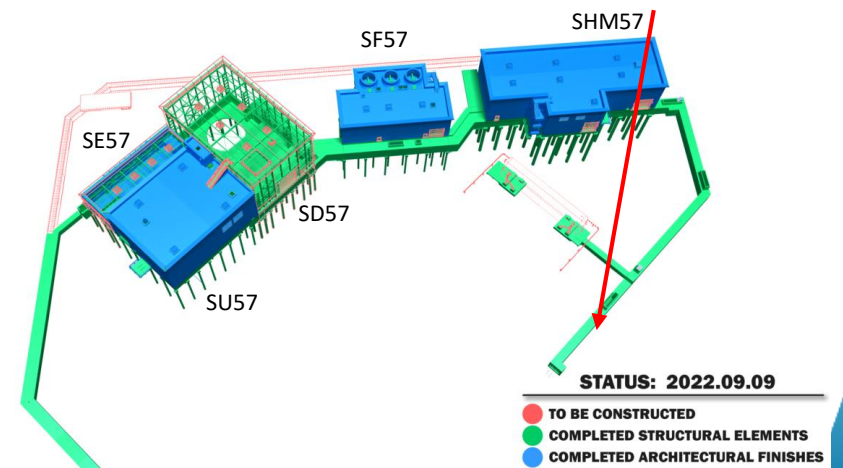
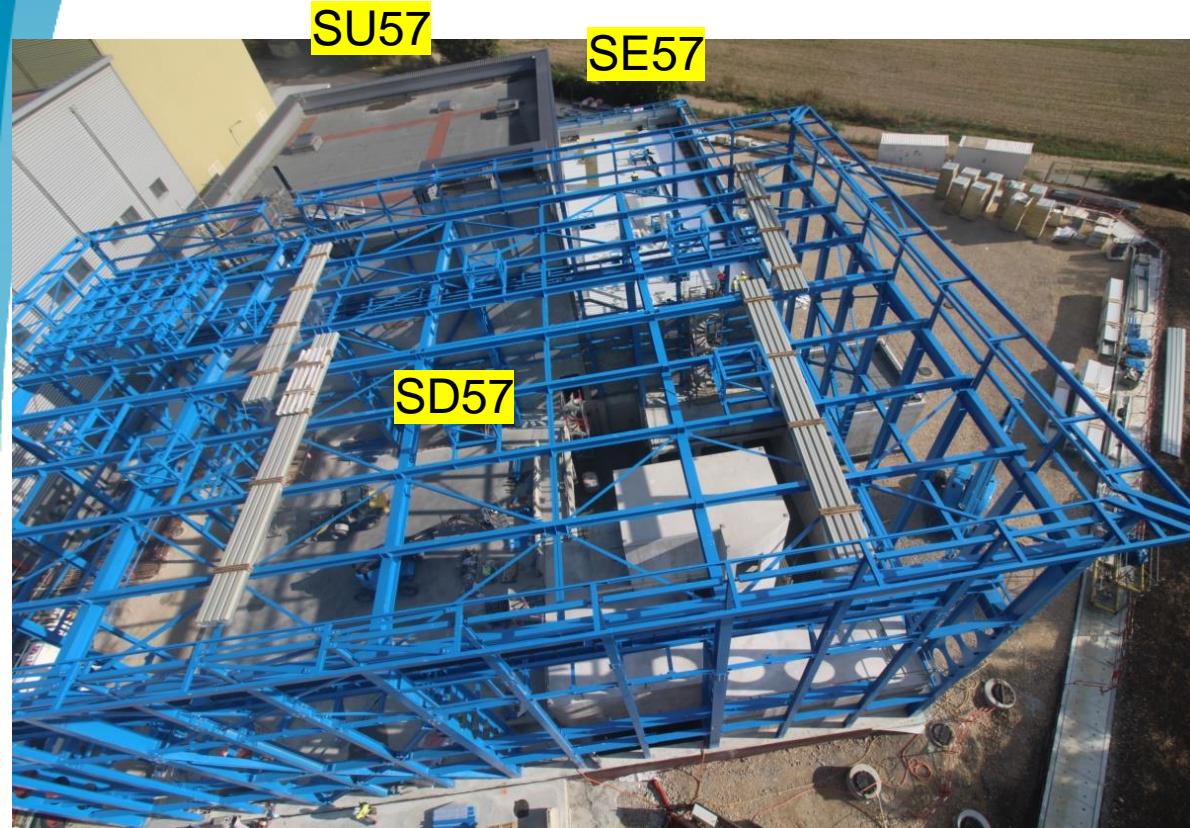
Pieter Mattelaer and Laurent Tavian

Main civil engineering work at Point 5 (CMS)



Pieter Mattelaer and
Laurent Tavian

Main civil engineering work at Point 5 (CMS)



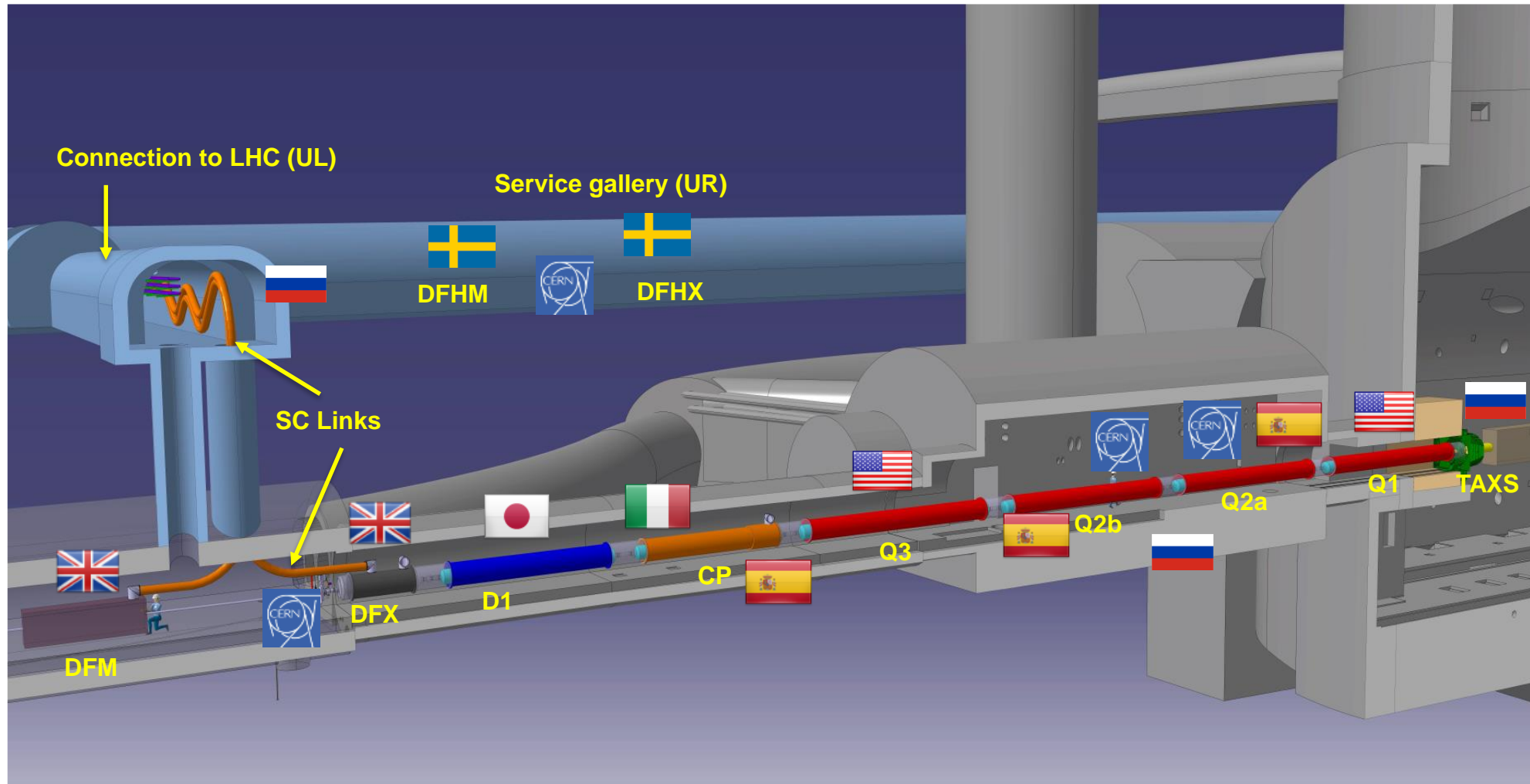
Pieter Mattelaer and
Laurent Tavian

Technical infrastructures in the delivered buildings

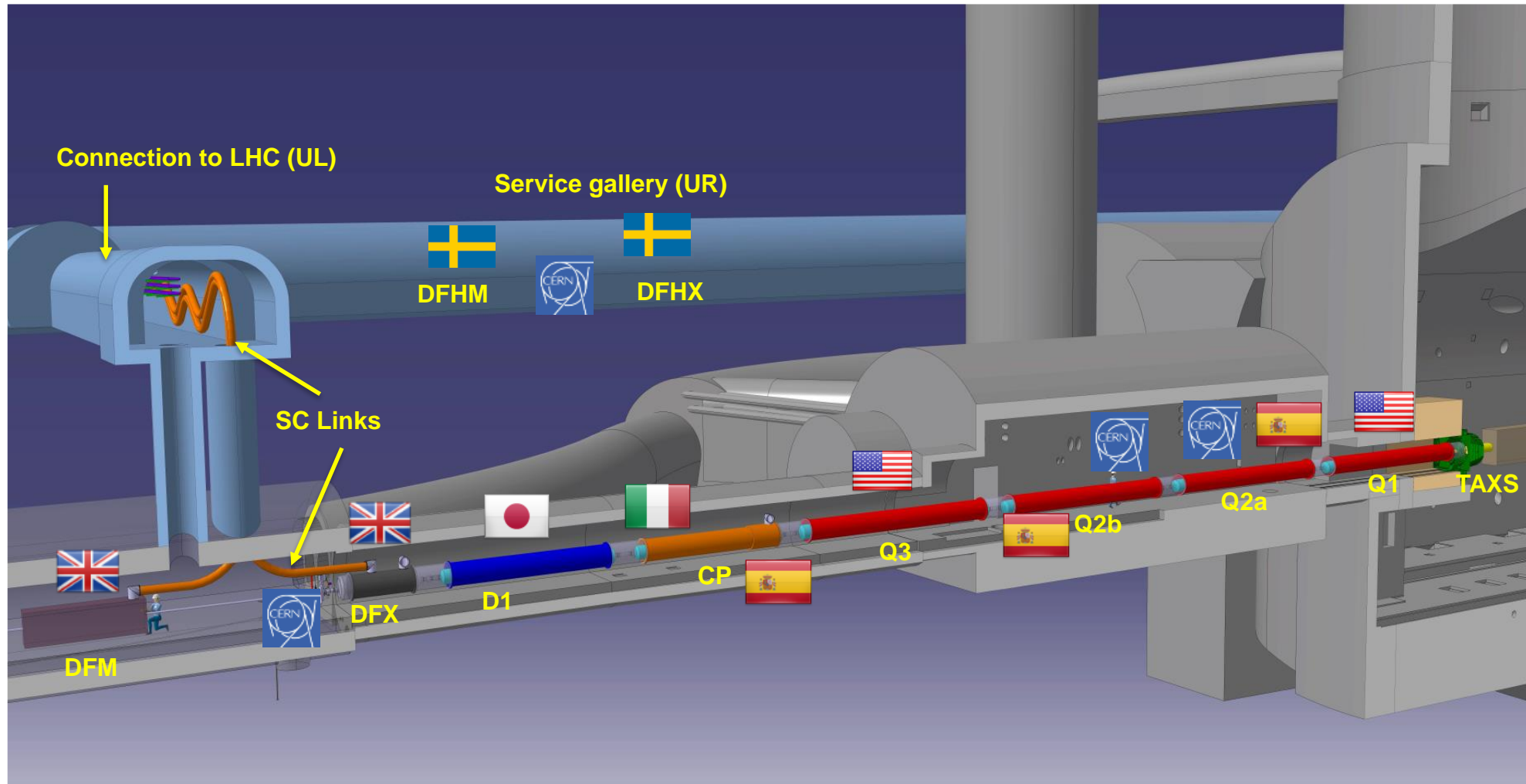
- Sectional doors
- Cranes
- Cable trays
- Lighting
- Ventilation system
- Primary water system



International Collaboration

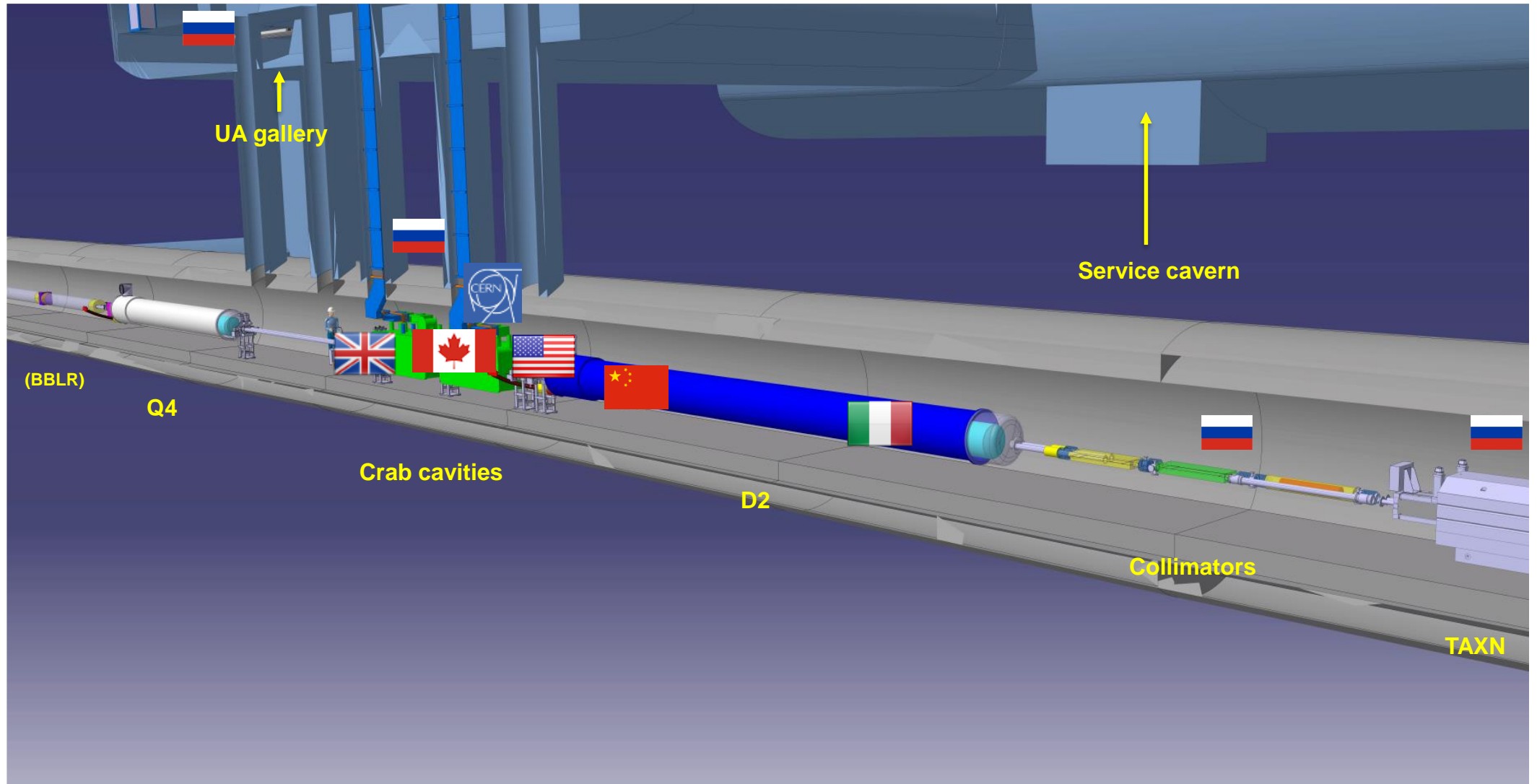


International Collaboration



Cancellation of several Contracts with Russia due to accumulated delays → Plan B implementations

The MS region with in-kind contributions



Cancellation of several Contracts with Russia due to accumulated delays → Plan B implementations

The MS region with in-kind contributions

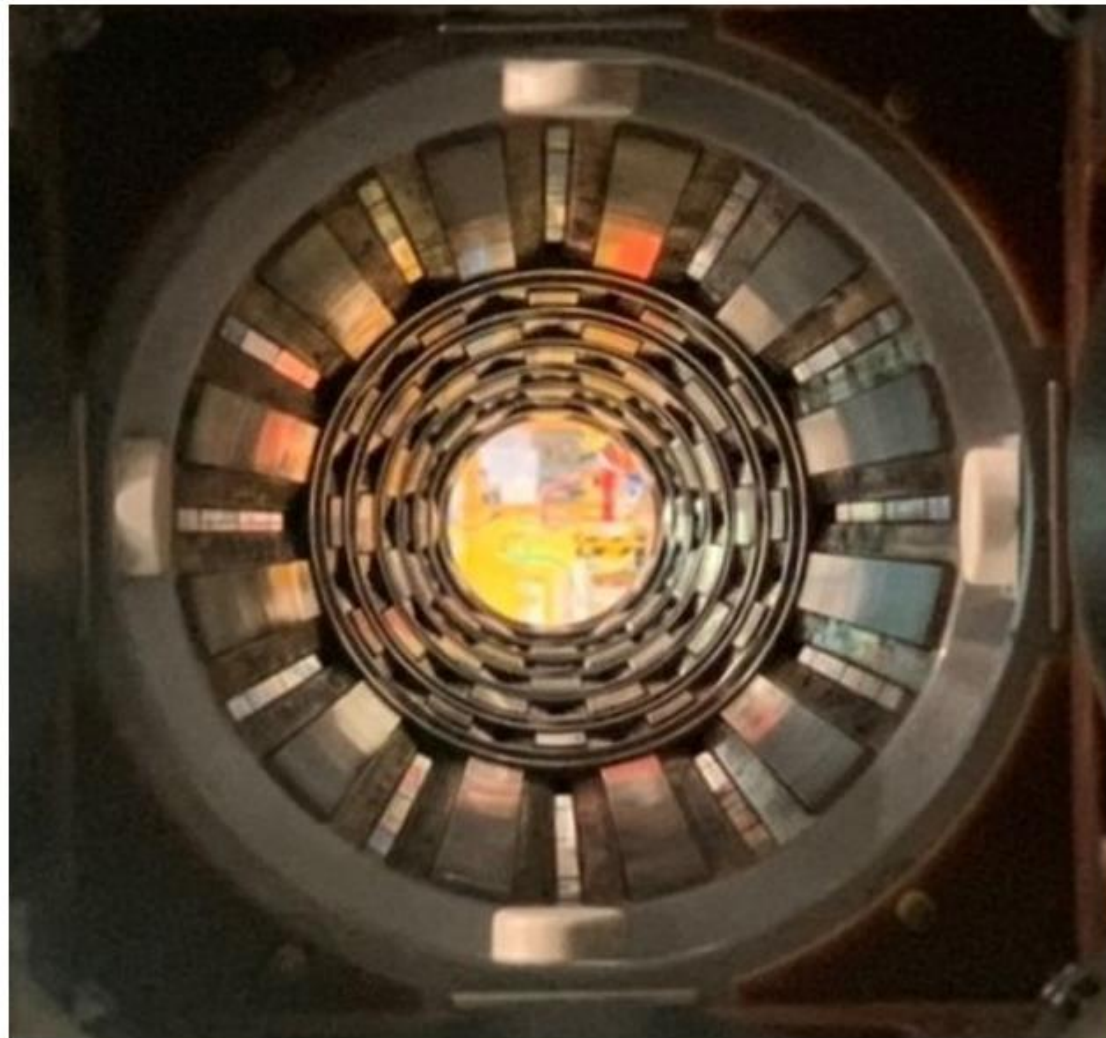


Cancellation of several Contracts with Russia due to accumulated delays → Plan B implementations

Timeline: Main Milestones in 2021

More details in
Marco Statera's talk

- November 2021: HO corrector manufacturing finished and assembly started ✓

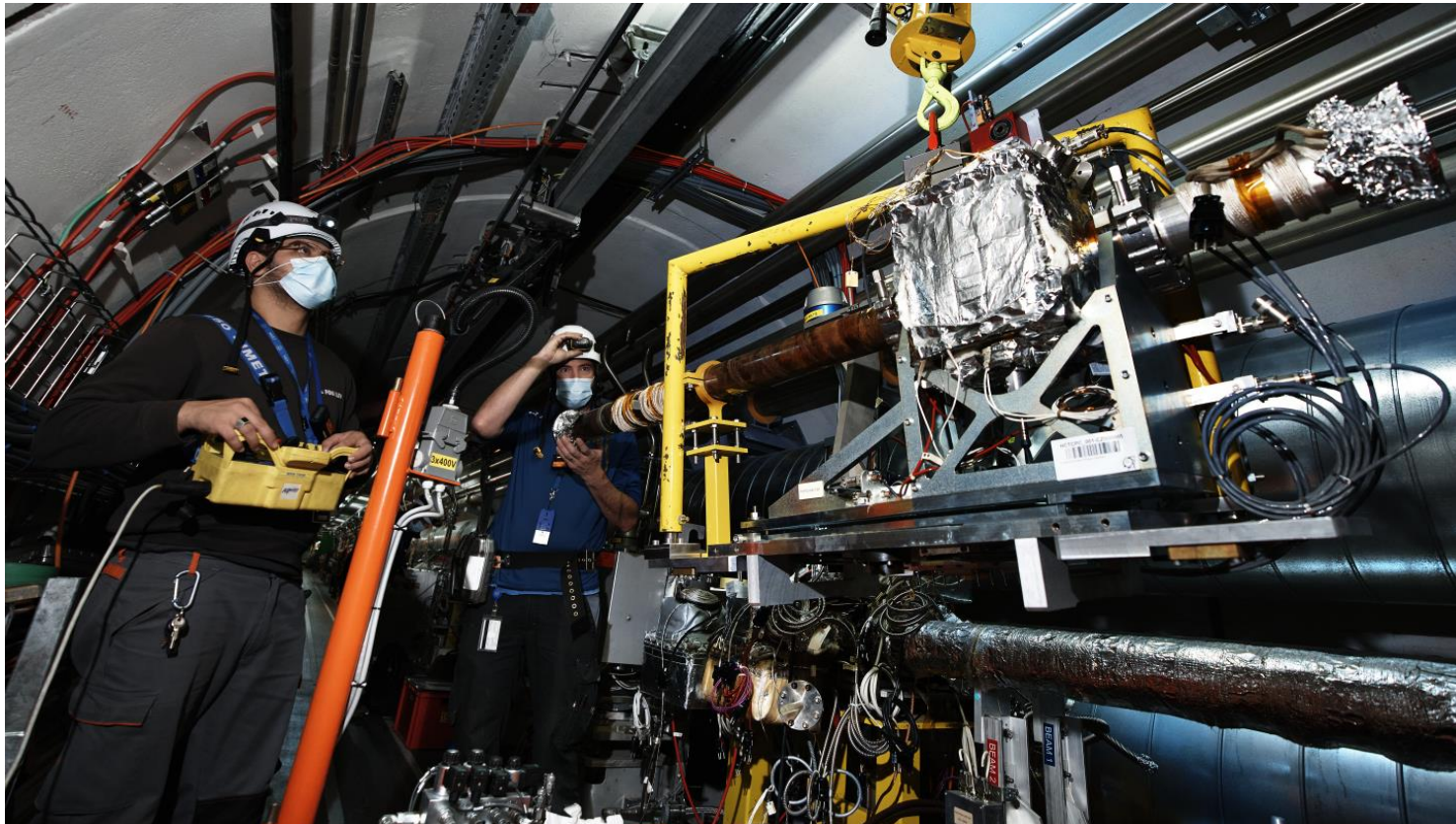


Sequence of higher order corrector magnets and preassembled cold mass of the Corrector Package [CP]

Timeline: Main Milestones in 2021

More details in
Srefano Redaelli's talk

- November 2021: HO corrector manufacturing and assembly completed ✓
- November 2021: Shipment of second RFD cavity from CERN to the UK ✓
- November 2021: CERN C&SR #5 → endorsement of presented budget update
+14.2MCHF CtC increase & [30MCHF to 60MCHF exposure warning] ✓
- November 2021: Installation of two Goniometers with Crystal Collimators in the LHC ✓



Update on RFD Cryo-Module



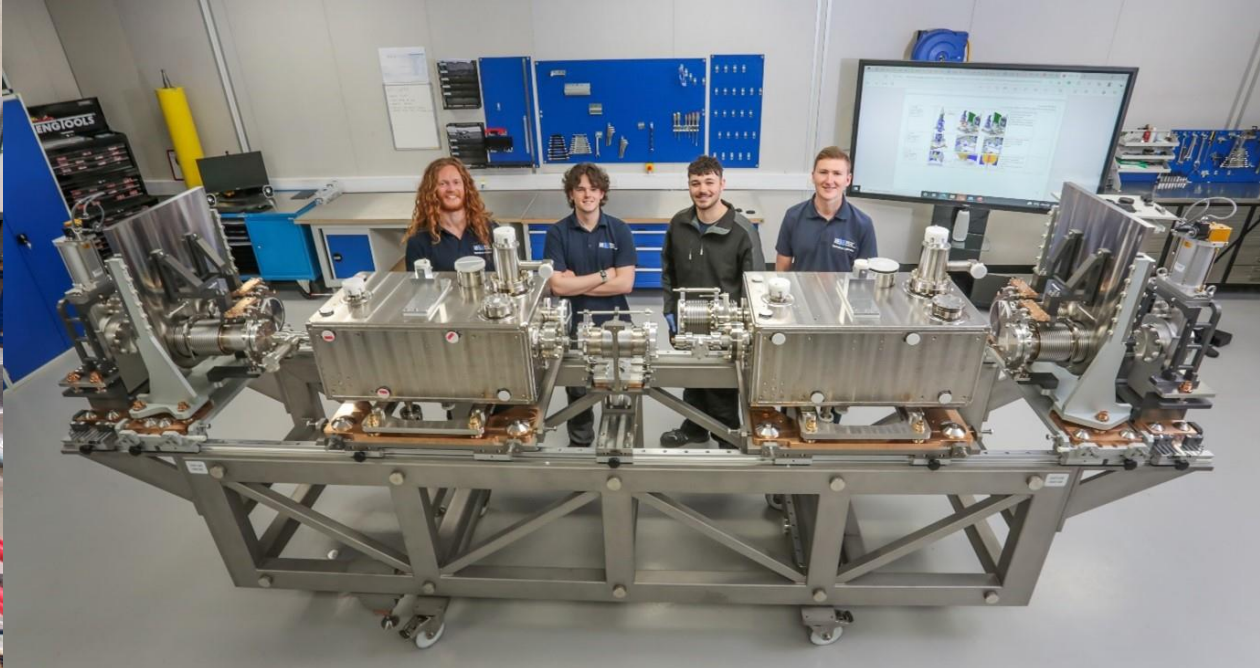
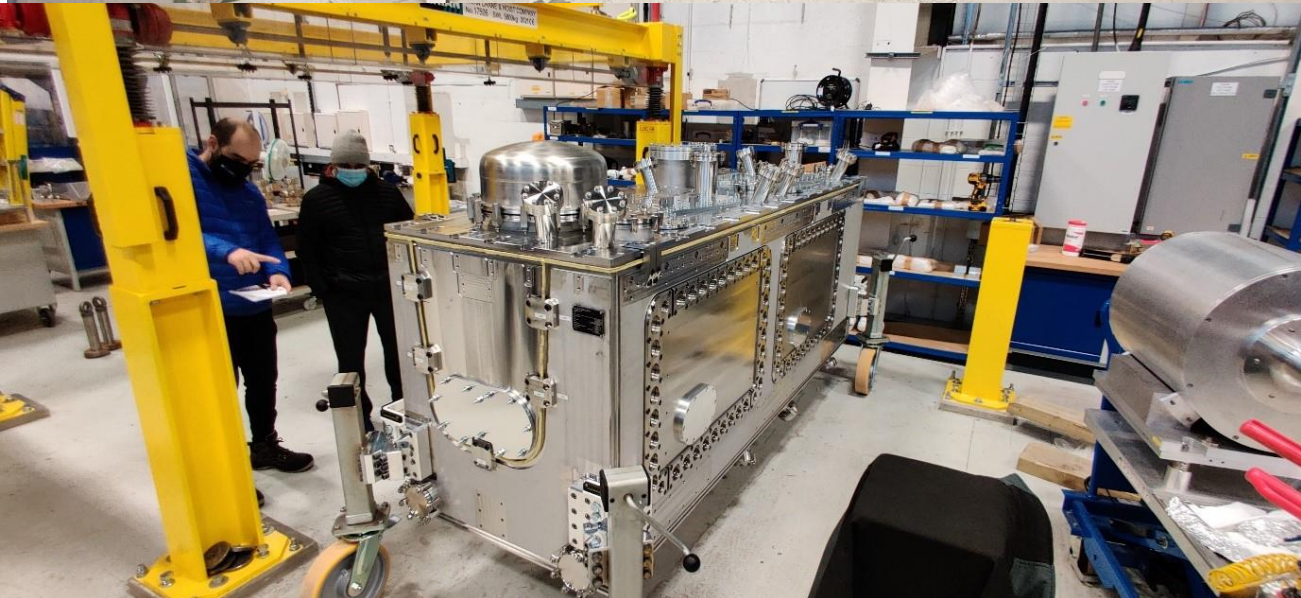
RFD Cavity in Transport Frame on arrival at Daresbury Laboratory

Cryo-Module on critical path for SPS installation during YETS 2022/23!

➔ Decision to delay installation until 2023/24

Outer vacuum Chamber

Cavity String prior to Cleanroom assembly

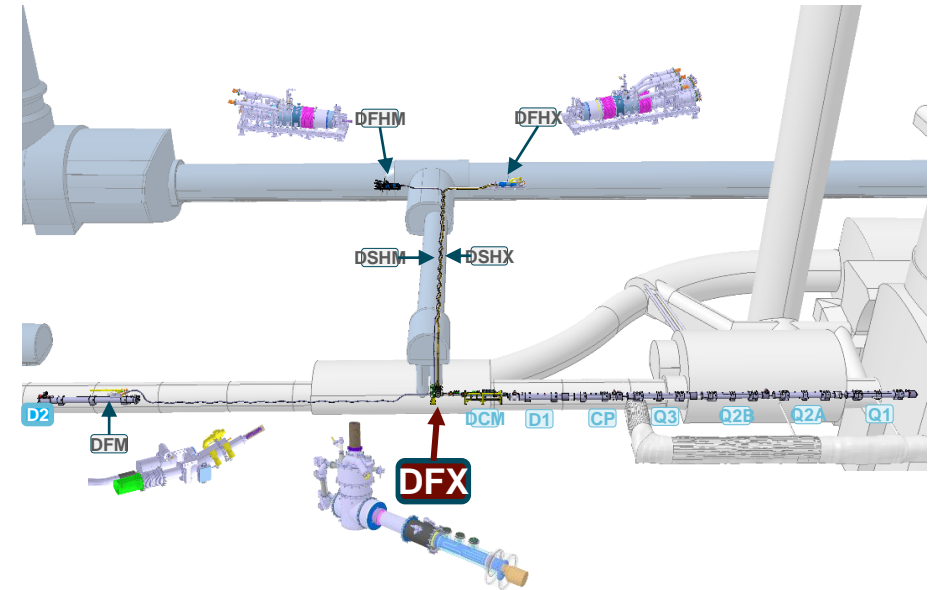


Timeline: Main Milestones in 2022

- January 2022: MQXFA08 fails to reach nominal current in vertical test [after performance limitation of MQXFA07 in September 2021] → coil manufacturing review [both magnet coils were produced during COVID years] ✓
- February 2022: full validation of DQW pre-series bare cavity build in industry ✓
- February 2022: Critical non-conformity of MQXFA09 → requiring disassembly ✓
- **March 2022: DFX Cryostat delivery to CERN** ✓

DFX Cryostat

Completed pre-series DFX by SOTON (UK1) !



CERN-UK1 collaboration under addendum #4 of KE3299/TE/HL-LHC

Design, Manufacturing, QC & CE certification under the responsibility of **Southampton University**

PRR 3 March 2020. 1.5 intense years from raw material procurement to completion of qualification and **CE certification** by notified body
Completed in March 2022 at LTI Metaltech & delivered to CERN

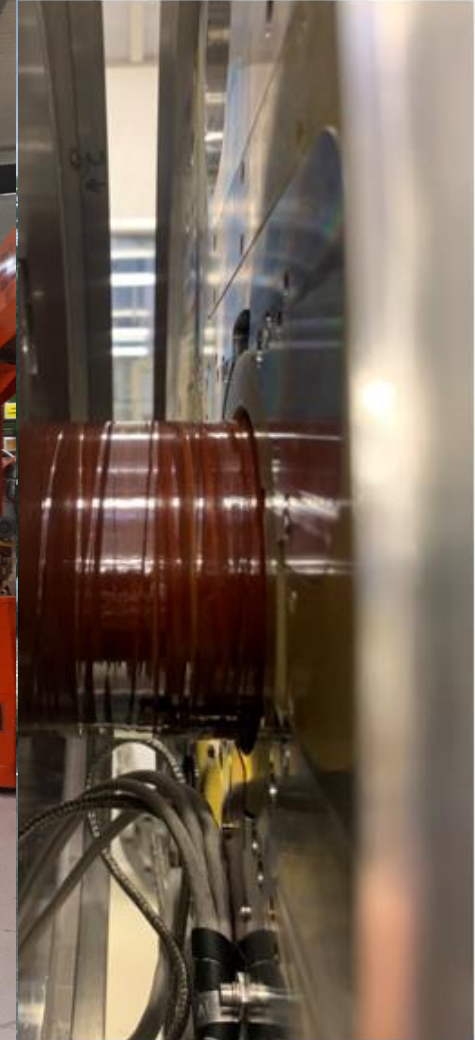
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- **March 2022: Cold-Mass assembly of D2 and nested Canted Cosine Theta corrector magnet ✓**
- **May 2022: Endurance Test on MQXFA05: 50 quenches, 5 TC → magnet remains @ nominal! ✓**
- **May 2022: Test of MCBXFBP2c at CERN in SM18 → reached full operation range at 7.5TeV equivalent current! ✓**

D2 Cold-Mass Assembly

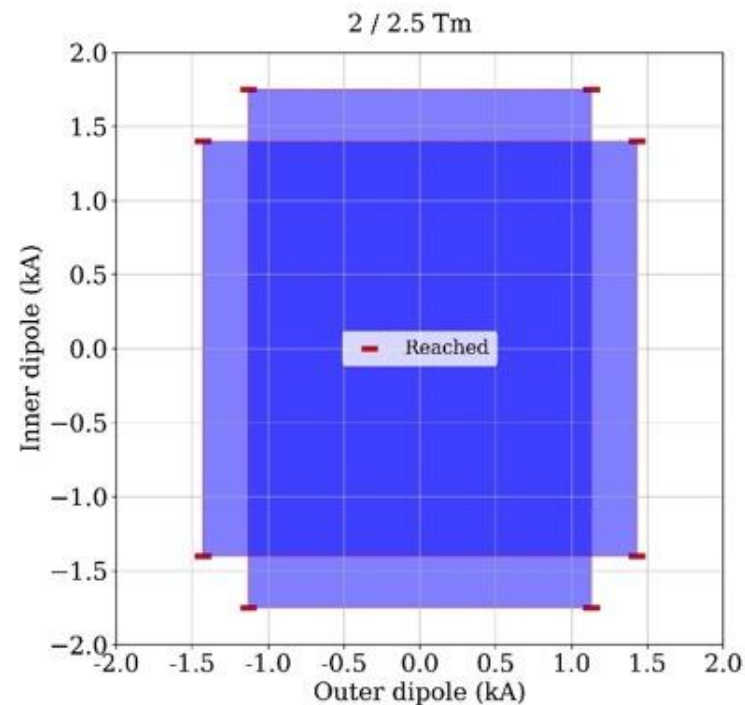
D2 Prototype on the test bench in SM18

D2 Prototype Col



MCBFBP2c: Cold Powering tests results

Design iteration on length of the inner coil produces successful performance increase!



More details in
Fernando Toral's talk

Ciemat Centro de Investigaciones
Energéticas, Medioambientales
y Tecnológicas

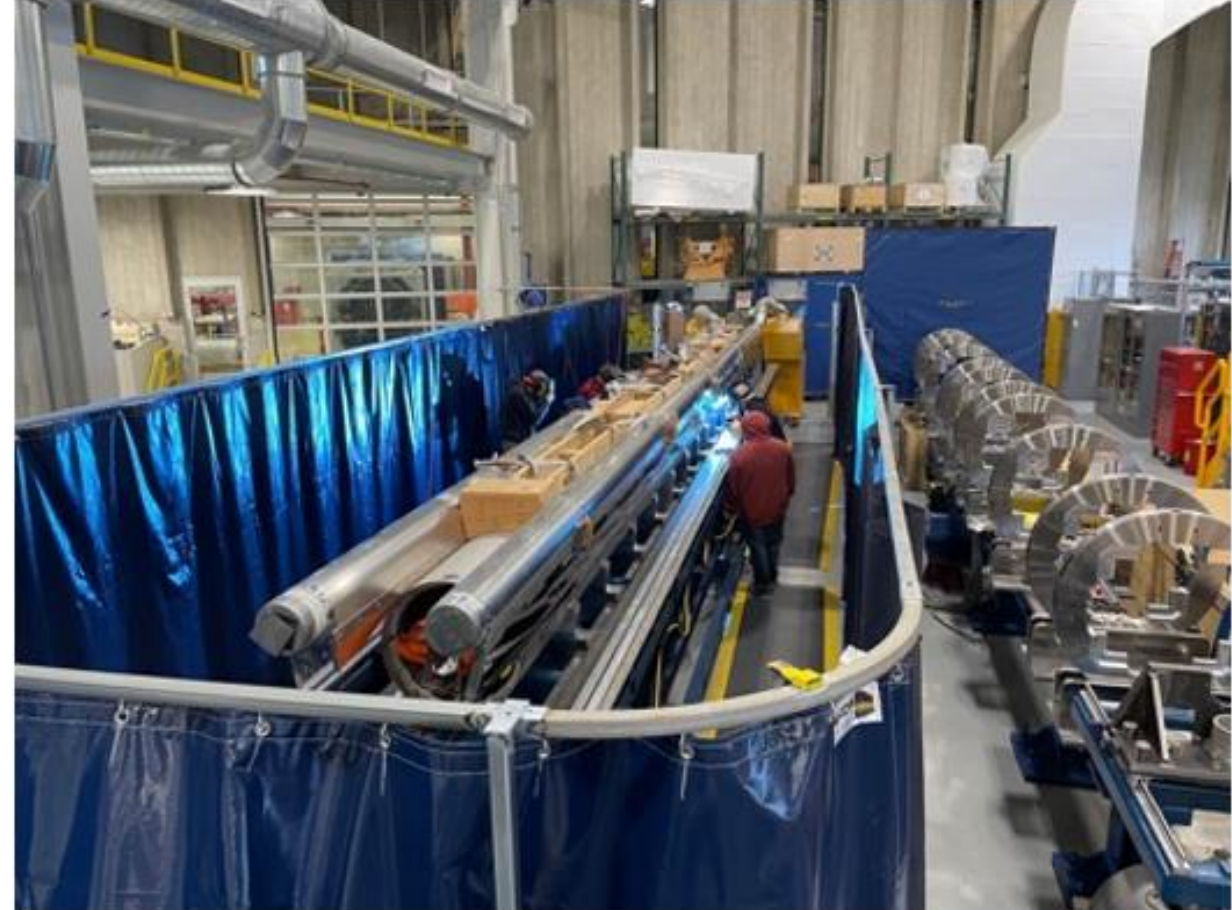


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- May 2022: PRR of US Crab Cavity Ancillaries production [HOM and pickup field antennas] ✓
- June 2022: Finance Committee approval of Industrial contract for IP1 and IP5 refrigerators
ca. +30MCHF CtC → [C-MAC!] ✓
- **July 2022: Successful vertical test of MQXFA10 ✓**
- **August 2022: Cryostating of MQXFA03 and MQXFA04 started following a review of the pressure vessel requirements and specifications**

Update on MQXFA Cryo-Module Assembly

Fitting of bottom SS shell and longitudinal welding



Update on MQXFA Cryo-Module Assembly

Integration of the Cold-Mass components and installation of end plates and pipes More details in Giorgio Apolinari's talk

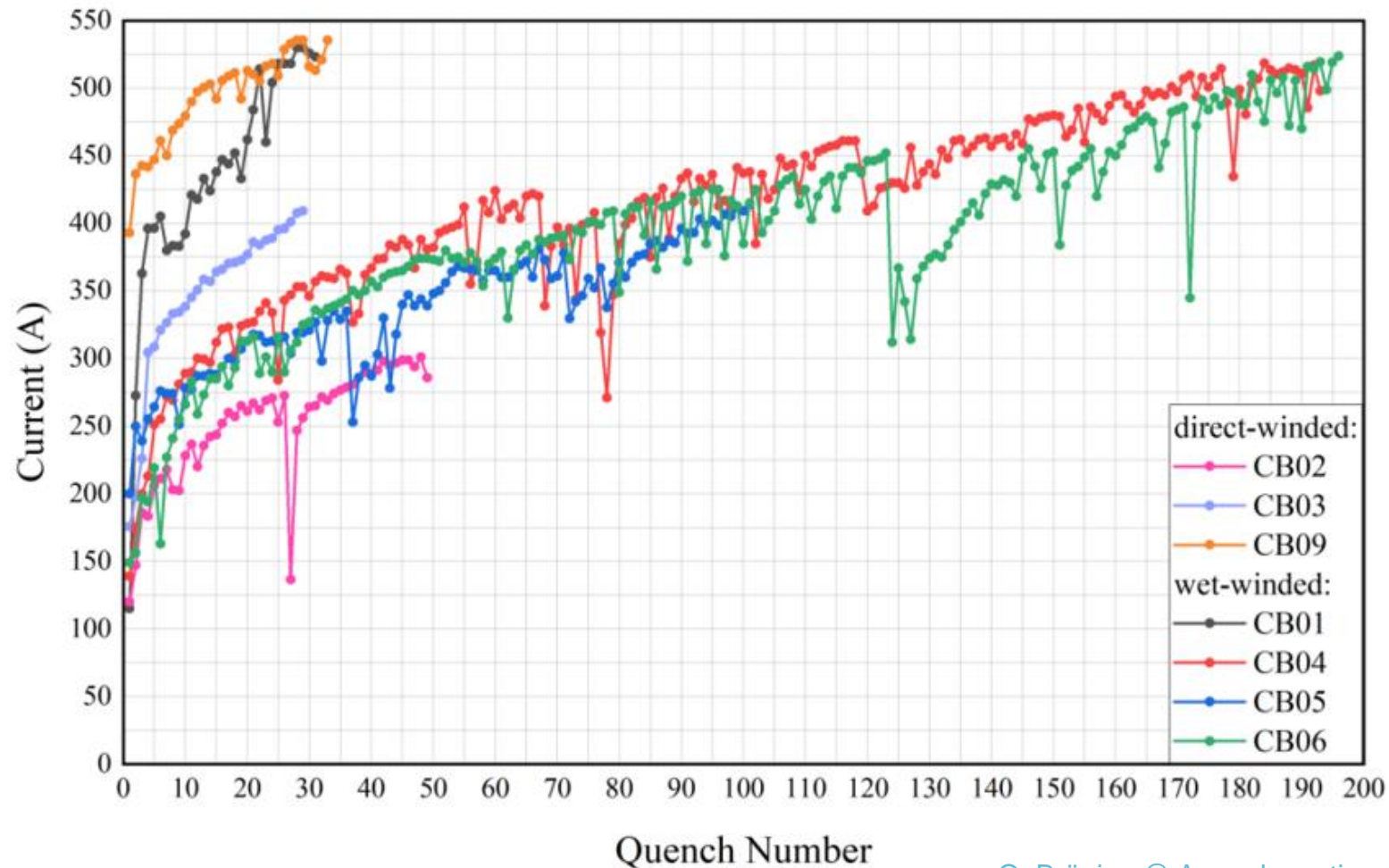


Timeline: Main Milestones in 2022

July 2022: Canted Cosine Theta Corrector production at BAMA in China → Iteration on former grooves and assembly and impregnation procedure: CB09 and CB12 train faster ✓

CERN Magnet MCBRDP4 also performs well!

Training History of the HL-LHC CCT Coils



More details in
Quingjin's talk

Timeline: Main Milestones in 2022

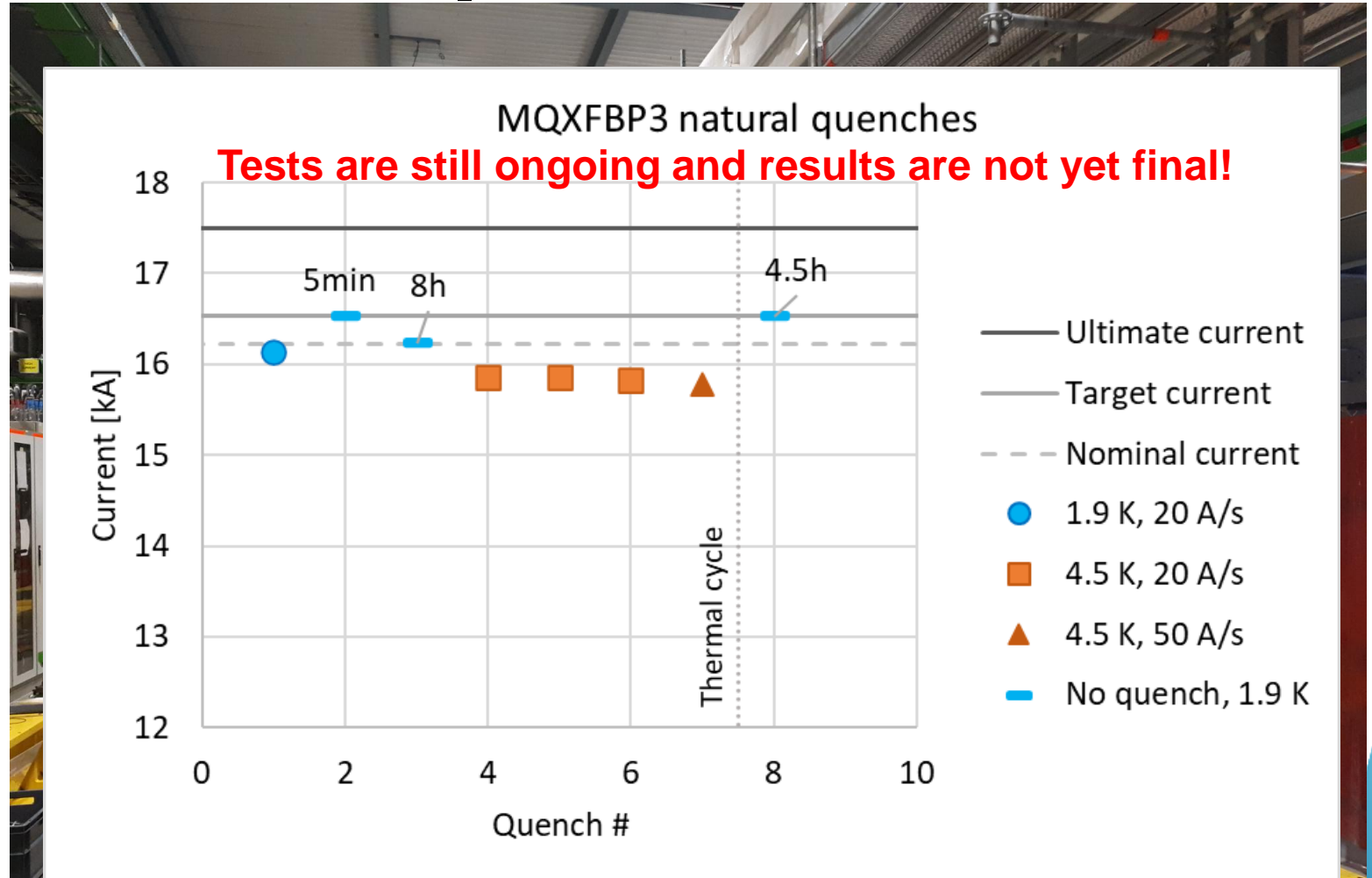
■ August 2022: MQXF BP3 test @ SM18:

Re-welded cold-mass from MQXF B01 with lower pre-stress of Stainless Steel shell

But still using coils from early 2020!

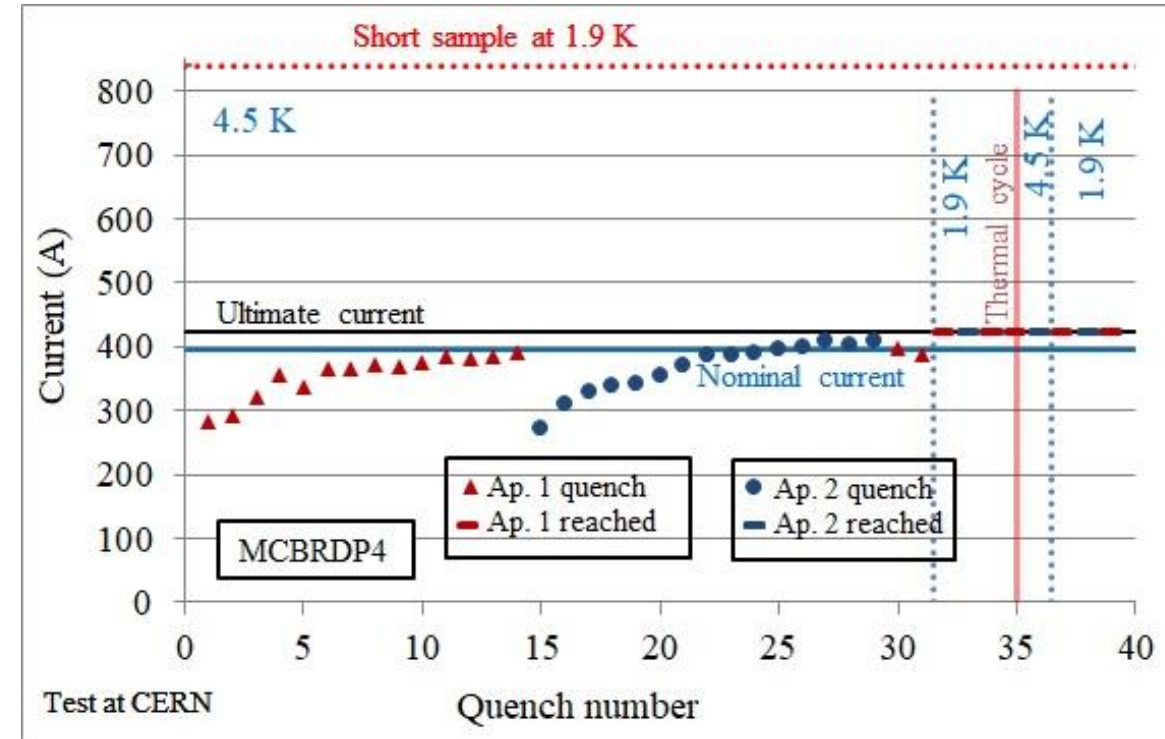
- Reached nominal+300A after 1 quench ✓
- Held nominal +300A for 8h ✓
- Showed a limitation at 4.5K
- Returned to nominal+300A without quench after TC ✓
- Held nominal+300A for > 4.5h

More details in
Ezio Todesco's talk



Timeline: Main Milestones in 2022

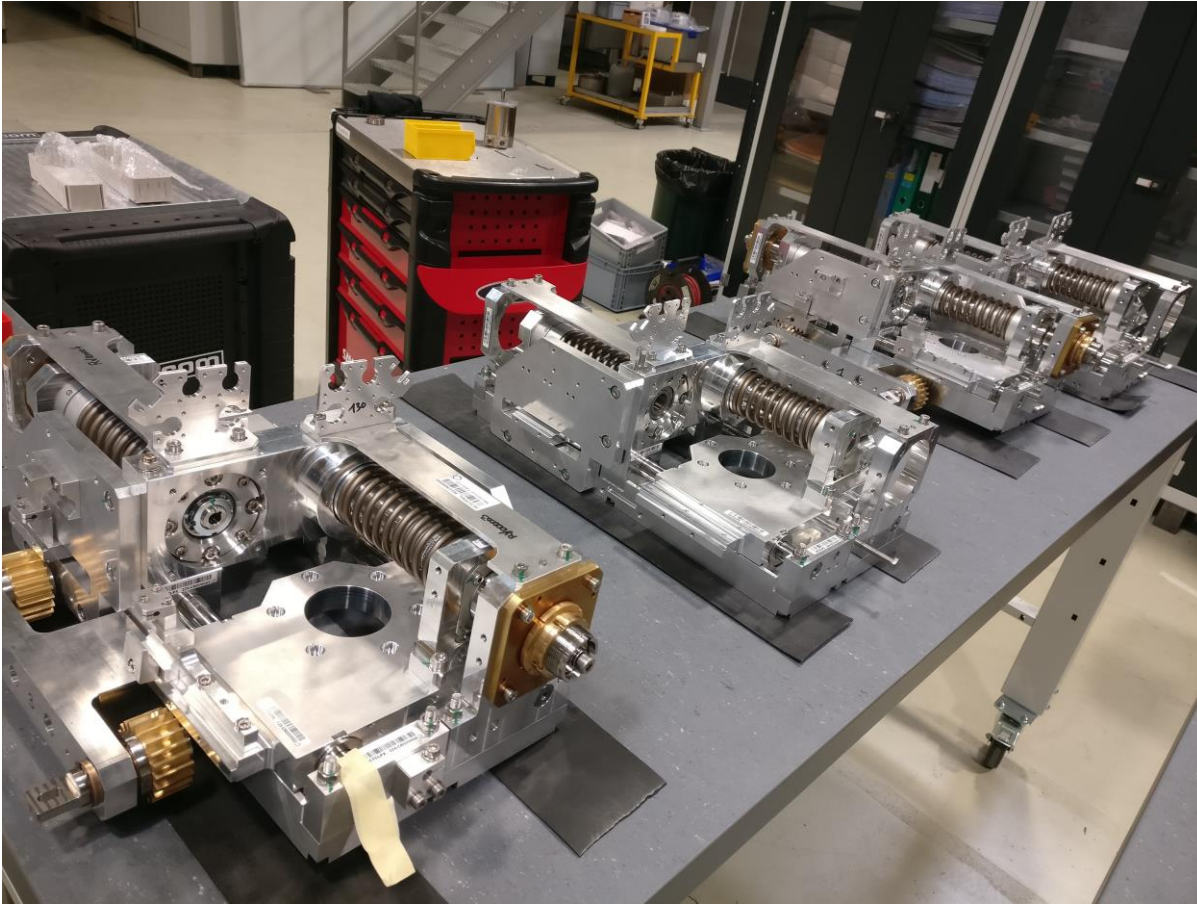
- End Summer 2022: cold test of 4th CERN MCBRD prototype [D2 corrector]



- End Summer 2022: Cold test D2 Cryostat in SM18
- End Summer 2022: cold test of first completed LQXFA cryostat & FNAL, pending assessment of welding issues
- Fall 2022: delivery of D1 Prototype to CERN
- Fall 2022: Cold test of MQXFB02 in SM18 [still using coils from 2020!]
- Fall 2022: Completion of HL-LHC Civil Engineering work
- YETS 2022 / 2023: completion of the Crystal Collimator installation in the LHC

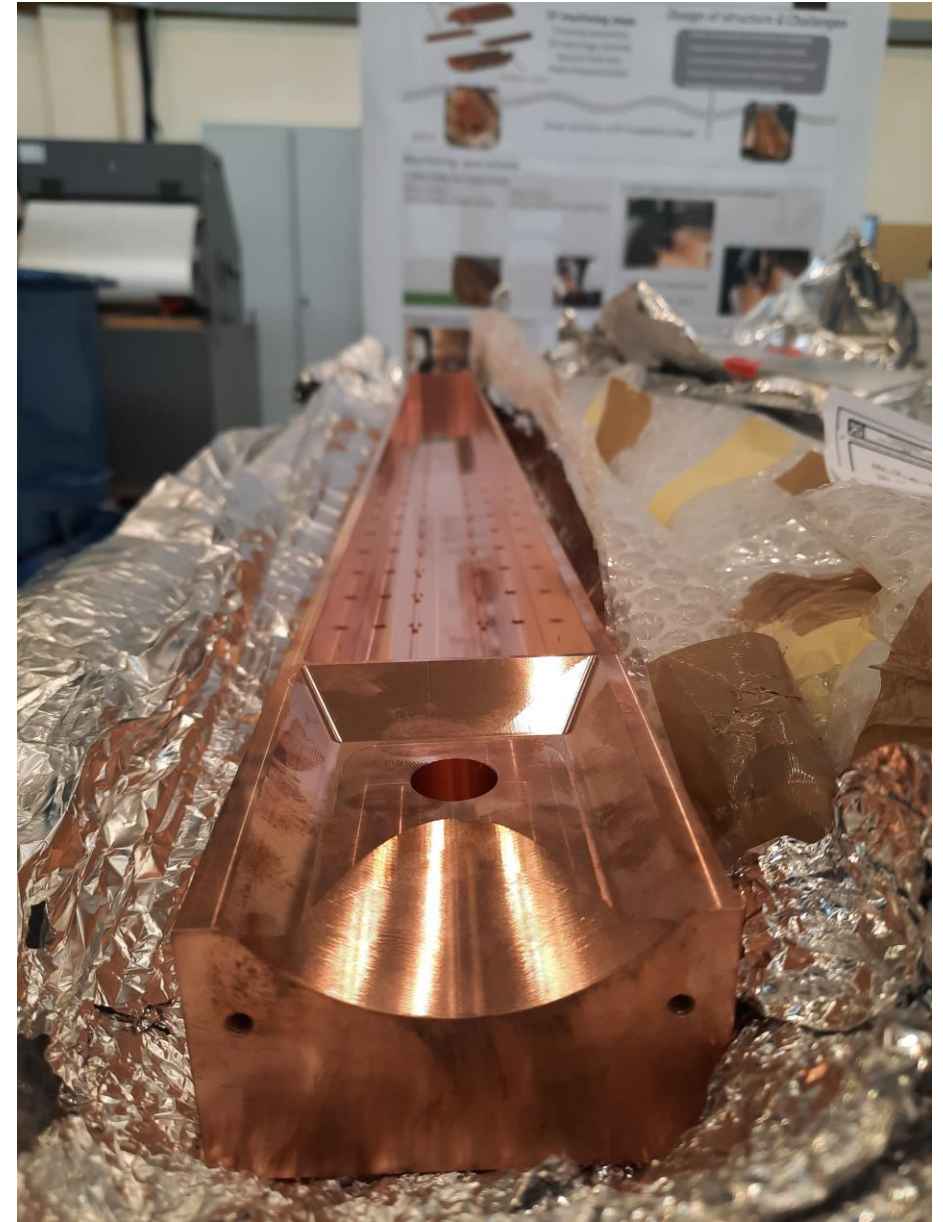
Timeline: Main Milestones in 2022

- Triplet Collimator Prototypes
TCTCPXH / TCLPX by Fall 2022



Collimator actuation system

Francois-Xavier Nuiry

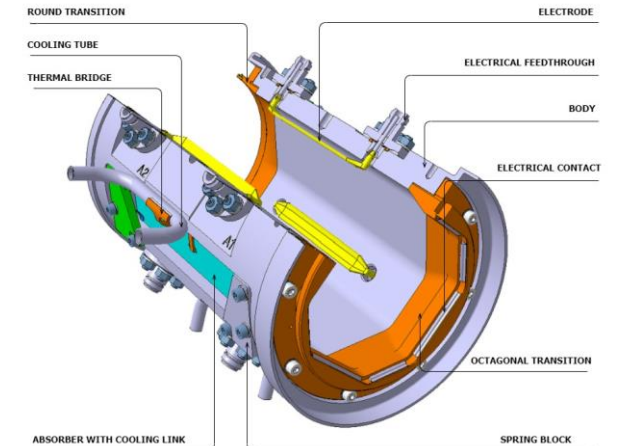
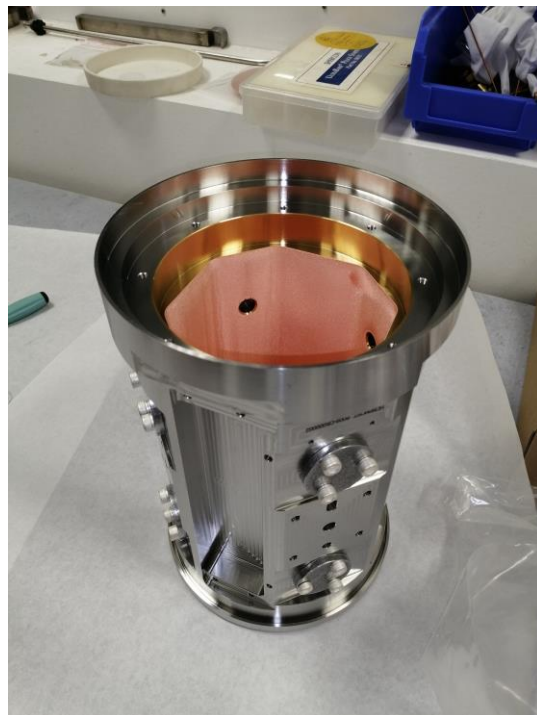
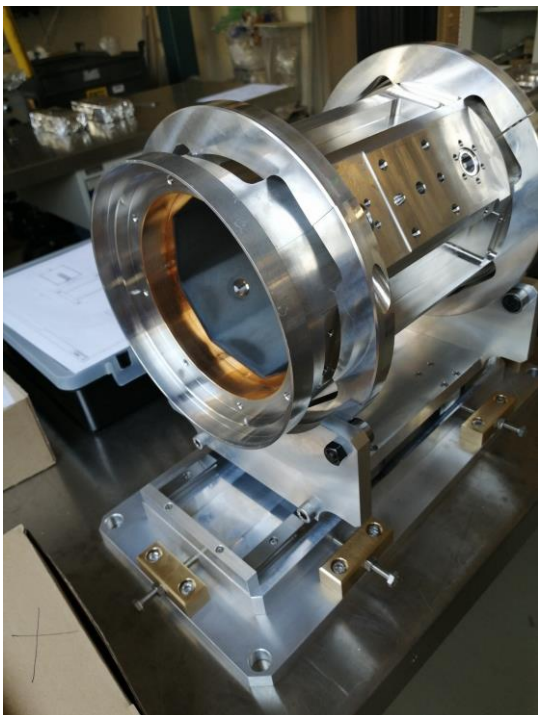


Collimator structural jaw

O. Brüning @ Annual meeting 19th September 2022

Timeline: Main Milestones in 2022

- BPMs:
Series production to start in October 2022



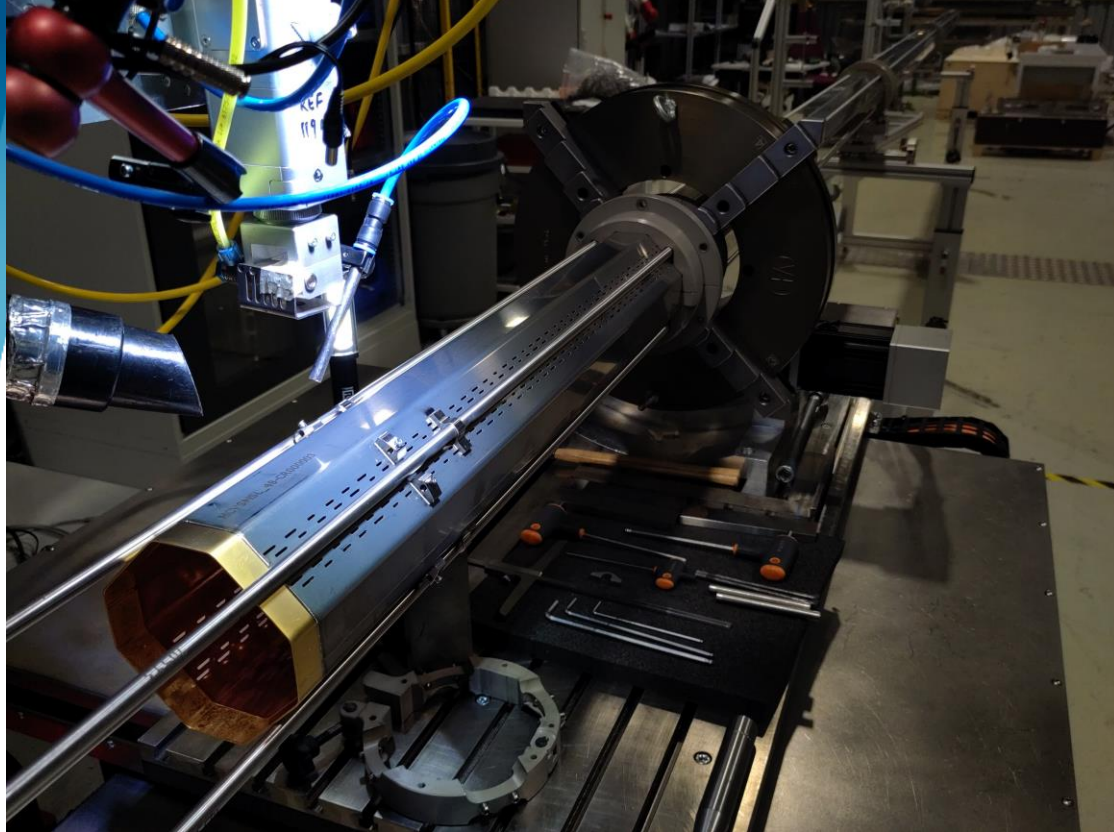
Timeline: Main Milestones in 2022

Beam Screens:

- End 2022: First Q2 type Beam Screen for the corrector package
- Mid 2023: First D2 type Beam Screen
- End 2023: First Q1 type Beam Screen

Cedric Garion

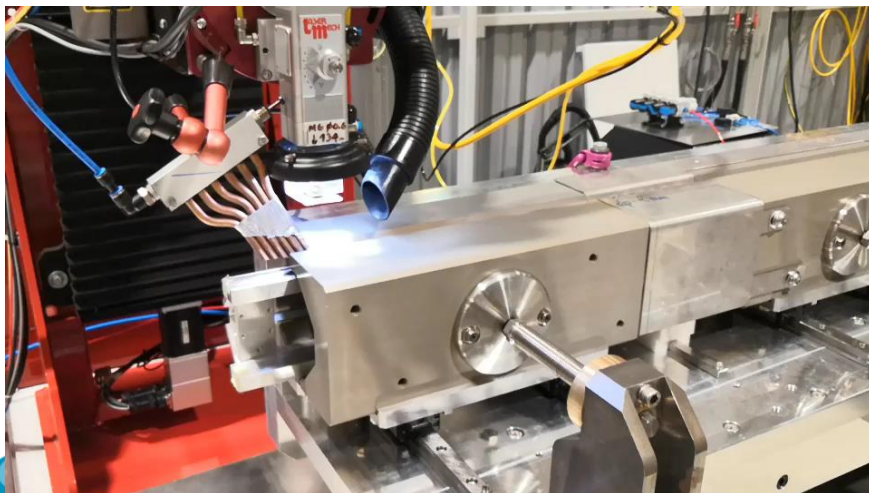




Fixed point laser welding



Fixed point laser welding



Longitudinal laser welding



Fixed point laser welding



Laser cutting simulation

SPS Test Program for CCs

- The DQW module (2021 & 22 & 23). Still in the planning:
 - Demonstrate max stable voltage (nominal required 3.4 MV)
 - Continue Emittance growth studies to understand the x3-4 discrepancy observed in 2018 between measurements & simulations
 - Intensity reach up to 4 batches of 72 bunches with LIU intensities – only possible in 2022 and beyond
 - Study instability limits caused by main CC mode?
- Swap to RFD module delayed until 2023-24 YETS. Validation program:
 - Max voltage, impedance, cavity alignment & operational aspects
 - Measurement of crabbed beams jitter & potential feedback
 - μ TCA development & deployment for crab LLRF (presently on VME)

System in SM-18 Overview

IT String Test Area

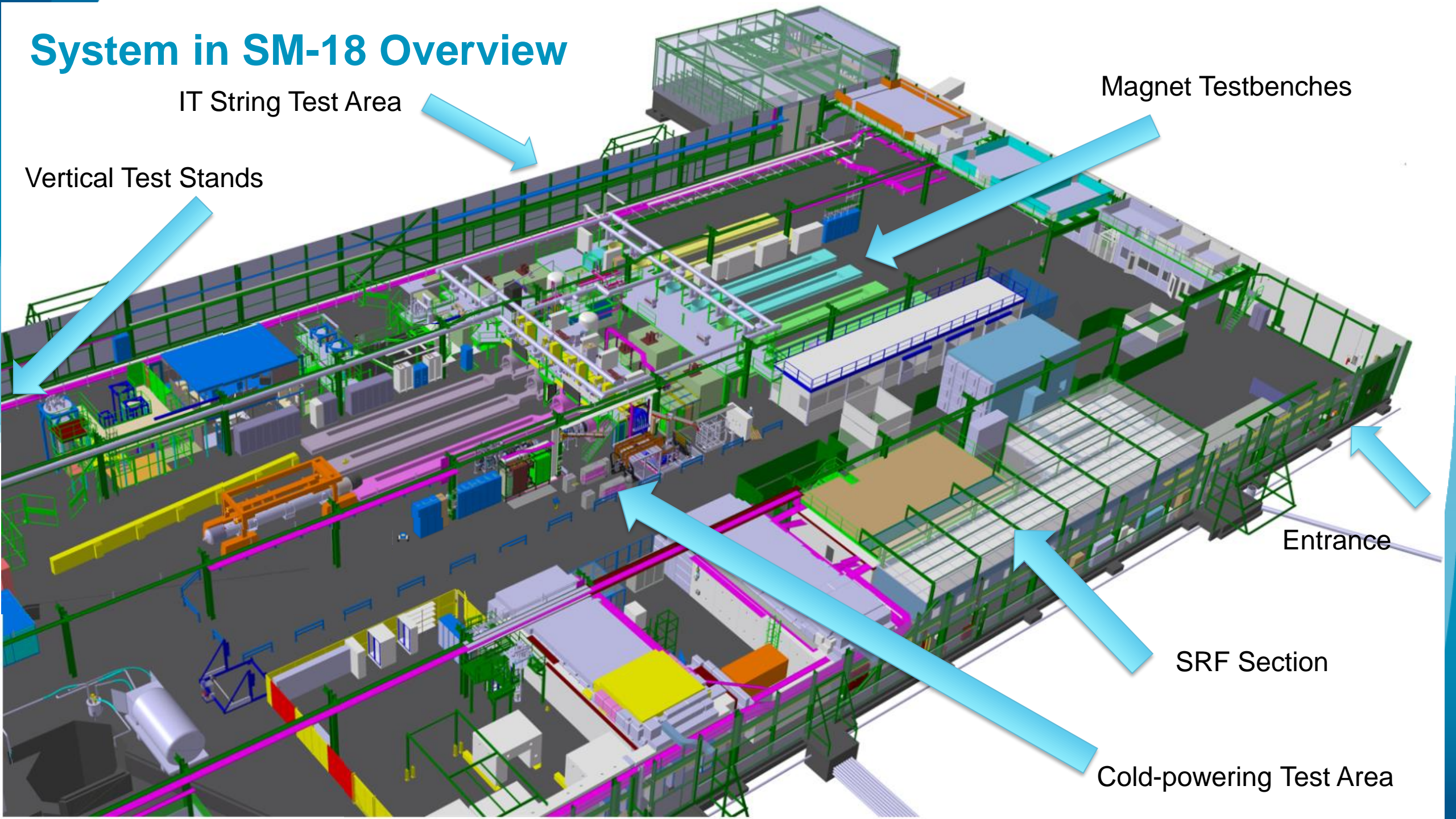
Magnet Testbenches

Vertical Test Stands

Entrance

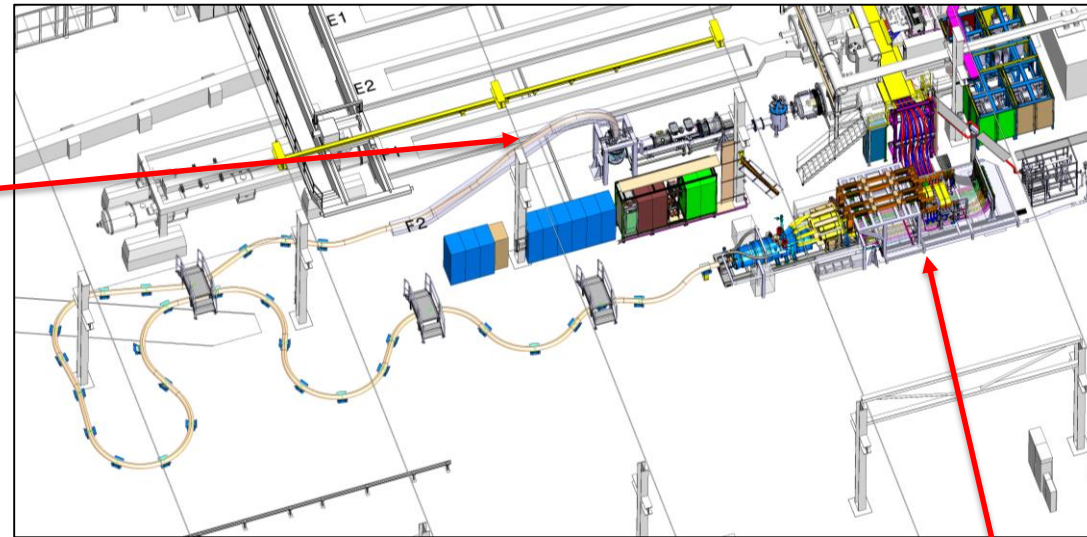
SRF Section

Cold-powering Test Area



Upgrade activities: Cold Powering

SC Link cable chain trials (SM18)

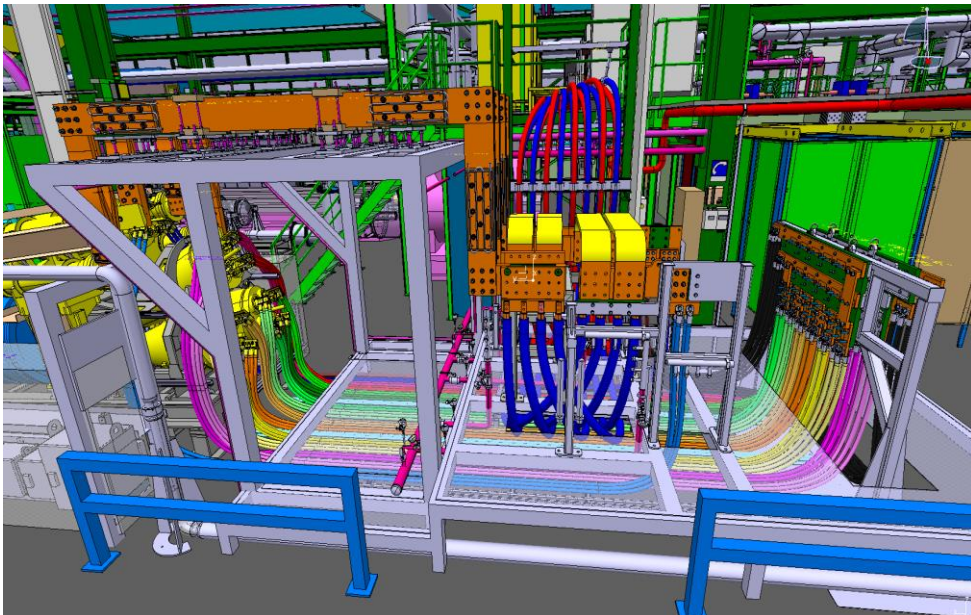


System test main equipment:

- DFX – SM18 pre-assembly
- DFHX – SMI2 pre-assembly
- Cu current leads – Bld 100
- HTS cable – in manufacture
- Sc link cryostat – Flex building
- Sc link cable – Bld 927
- CL heater rack – SM18
- QDS racks – SM18
- CFB shuffling module – SM18

SM18 Cluster F2 Test Bench Safety Assessment, edms 2703683 by T.Otto.

Patch Panel is taking shape....



Patch Panel Assembly:

- Support structures - installed
- CRG helium panel - installed
- WCC - installed,
- WCC cooling - ongoing
- ACC installed,
- Signal cabling installed,
- Cu parts PPI installed
- Cu parts 18kA busbar - delay
- IP2X cage - in manufacture

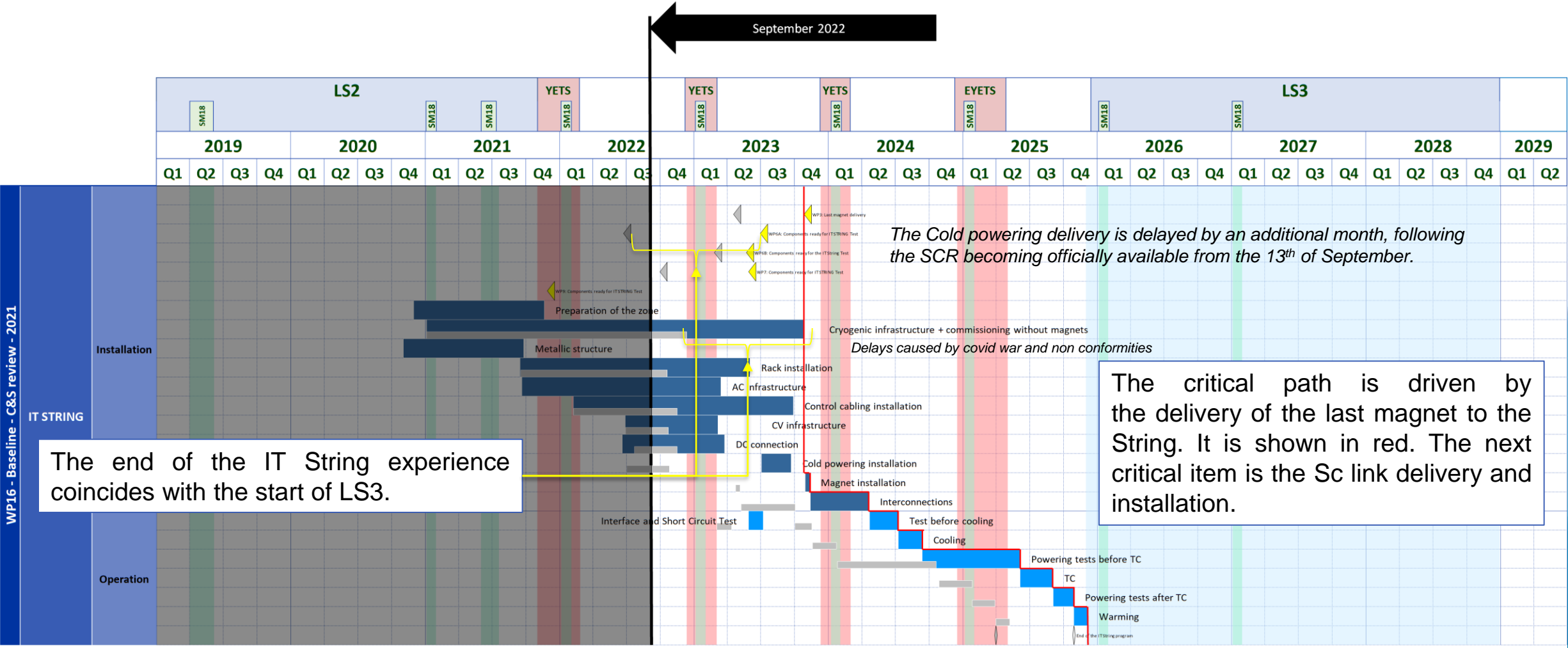


More details
in Marta Bajko's
presentation



New IT String Schedule

More details in Marta Bajko's presentation



Seeing the light at the End of the Tunnel

Overall Great Progress in 2022 on all fronts in spite of various crisis!!!

Passed ½ Point in terms of Project Spending and EVM!

Congratulations to all teams, Collaborators and Work Packages!

Project is on track for Series production of HL-LHC components



End Transparencies

SM18 upgrade project – Scrutiny outcome

- Important upgrade of CERN’s SM18 test facility is required to allow for the testing of (pre-)series magnets, current leads and cold powering systems (sc links and feedboxes) for the HL-LHC project
- A Scrutiny group was established to request, assure conformity with needs beyond the HL project scope
- Detailed report and choices while making cost sharing
- DMR on the implementation

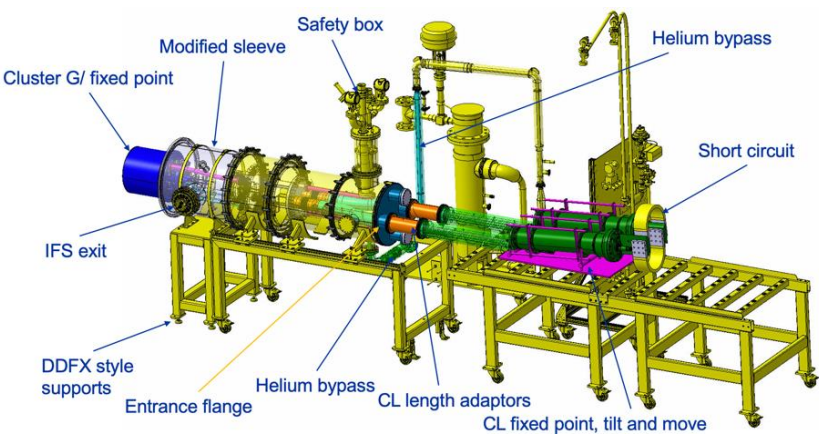
Updated schedule for magnet availability for IT String Test!

→ Updated Schedule for String Test – operation now planned to extend well into 2025

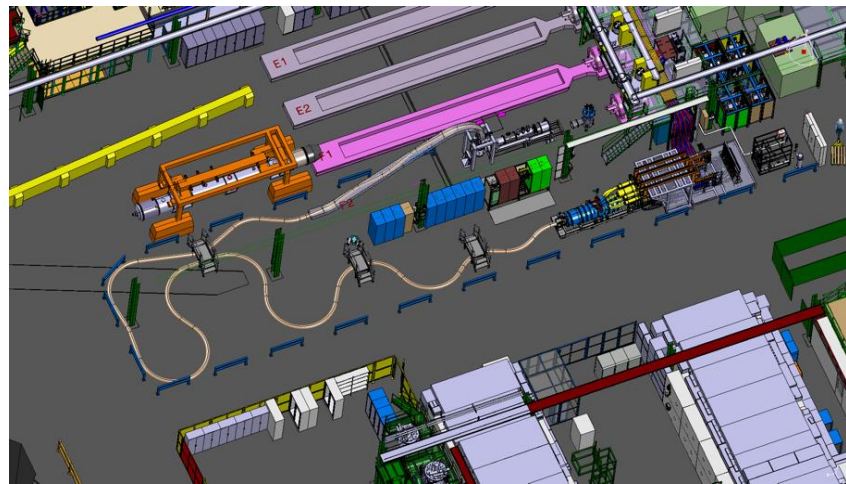
request, assure with needs beyond

ness of technical quality assurance and

[2637180/1.0](#)



HTS current lead testing

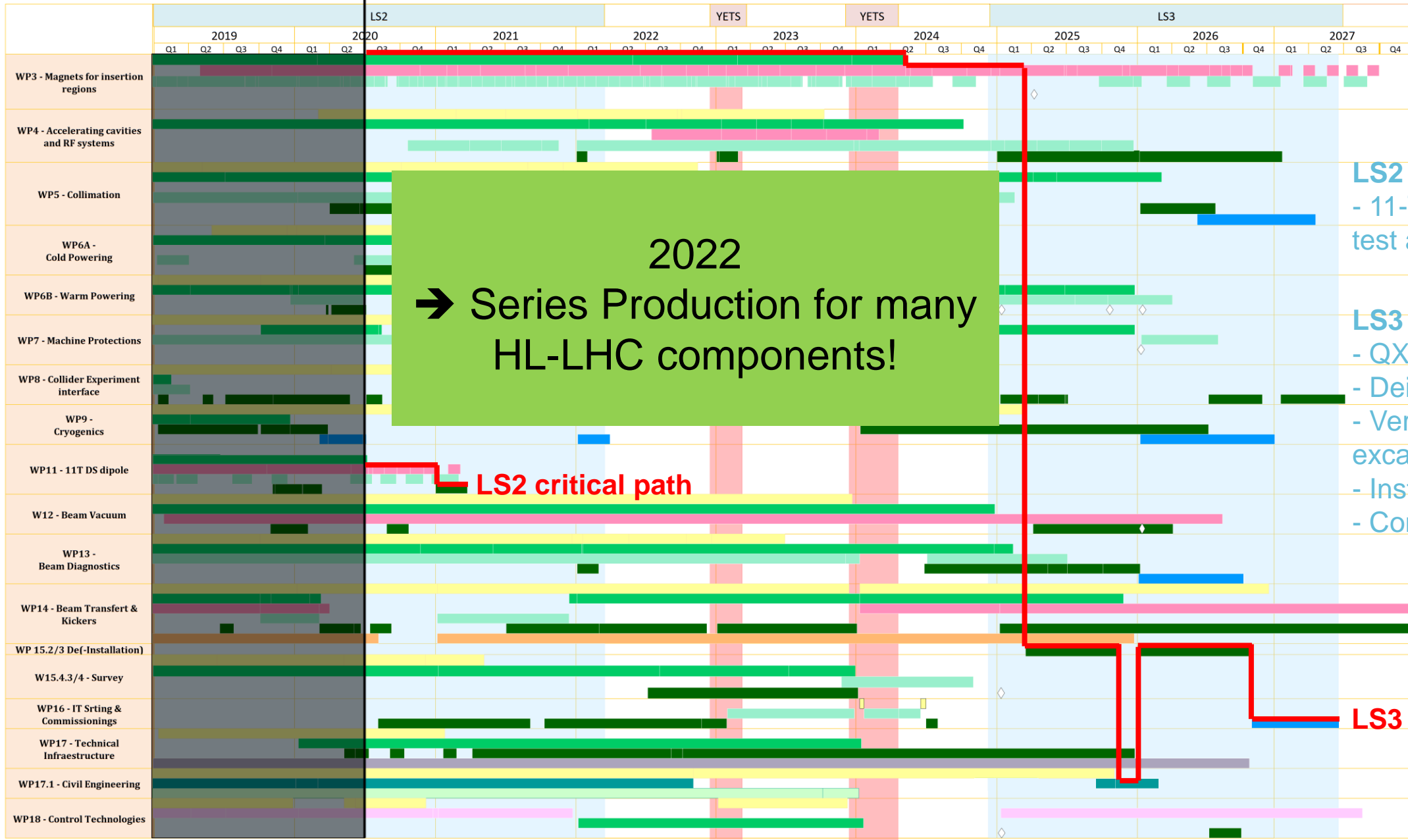


Test station for sc link and feedboxes



Magnet test benches

← July 2020



2022
 → Series Production for many
 HL-LHC components!

→ **LS2 critical path**

LS2 critical path:
 - 11-T dipole assembly,
 test and installation

LS3 critical path:
 - QXF assembly & test
 - Deinstallation
 - Vertical core
 excavation
 - Installation
 - Commissioning

→ **LS3 critical path**

LEGEND



Added Scope since C&SR 2019

RA63

