



HL-LHC Circuit Instrumentation Day 2023

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Intro and recall of 2020 recommendations

M.Zerlauth

Acknowledgments: L. Bottura, M. Pojer, A. Siemko, R. Van Weelderen, S. Yammine, S. Pemberton, G. D'Angelo, F. Rodriguez Mateos



Scope of 2023 review

- ⑩ Following the HL-LHC Circuit Instrumentation Detailed Design Review in September 2020 ([link](#)), the scope of the HL-LHC Magnet Circuit Instrumentation Day 2023 is to **perform a final check of the requirements, of the implementation and of the commissioning practice for the instrumentation for the superconducting magnet circuits** of the Inner Triplet, D1, D2 and the related correctors in light of the imminent implementation in the HL-LHC IT String facility.
- ⑩ **The scope includes quench detection and monitoring systems, interlocks, cryogenics instrumentation and vacuum instrumentation.** Their variations **in the HL-LHC IT String** with respect to the tunnel baseline shall be highlighted.
- ⑩ Furthermore, the scope comprises the **design and the testing** of the system components and wiring.

Expert panel composition and charter

- **Experts and Scientific Secretaries**
 - Davide Bozzini
 - Juan Casas-Cubillos
 - Jean-Philippe Tock
 - Scientific Secretaries : Alvaro Santiago Ferrer and Shruti Seshadri
- **Charter**
 - to **verify the implementation of the instrumentation baseline** for a reliable long-term operation of the machine;
 - to **verify the completeness and adequacy of the instrumentation test and commissioning strategy** from individual components to the integrated systems;
 - to **ascertain that the related documentation is consistent** across the different stakeholders.

Executive Summary 2020 review

- The panel would like to thank and congratulate the organisers, speakers and participants for their efforts in the preparation and conduction of this important review for the HL-LHC instrumentation
- We have been presented with a comprehensive overview of the current understanding of the instrumentation baseline and associated hardware developments
- The panel considers this a first functional review of the instrumentation, allowing to converge and approve the instrumentation baseline for the machine configuration
- A detailed design review should be conducted in the near future

Review Recommendations 1/10

R1: Clarify the level of quench heater redundancy for the D1 magnet (i.e. number of quench heaters necessary for nominal operation in tunnel)

- Clarified by A. Musso. Unavailability of a single QH circuit is still acceptable for protection/operation. Quench heater circuit layout optimised to assure redundancy between high-field and low-field heaters. Detailed documentation in EDMS Doc Nr. 2257328 and 2412615 ‘Quench Detection Scheme and Monitoring Baseline’ – J. Steckert

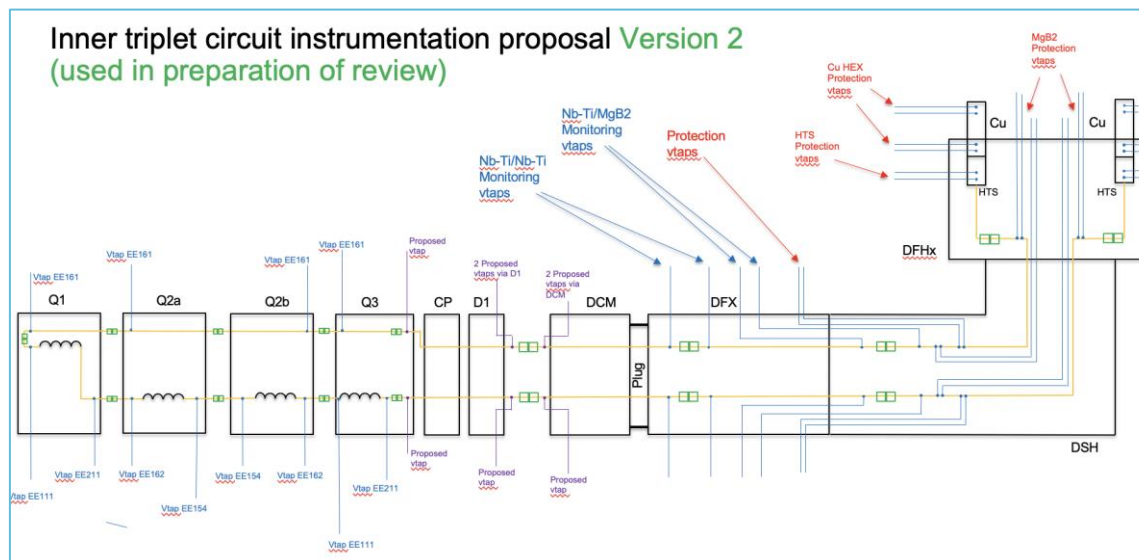
R2: Connection method of (redundant) V-taps should be clearly defined, documented and coherently applied for all circuit parts

- Protection channels (UQDS) are by definition using redundant V-taps (for protection of coils, splices, busbars, sc link,..). If attached to the same location on circuit, connection scheme should be clearly documented and specified (both wires soldered on same spot, with distance,...) ‘Connection and Integration of Instrumentation in the Magnets’ – H. Prin

Review Recommendations 2/10

R3: A coherent documentation of the overall circuit instrumentation must be established, shared and approved between all WPs (including all protection as well as monitoring needs)

- Building on documentation of individual WPs (WP3, WP6a, WP7,..) global & coherent approach is needed to assure protection at circuit level (including busbars, interconnection splices,..)



‘Layouts for HL-LHC Quench Detection Instrumentation’ – A. Santiago Ferrer

Review Recommendations 3/10

R4: CLIQ leads and (identical) k-mod leads are to be included in the protection baseline (through monitoring during discharge/powering)

- Included in latest instrumentation scheme, requiring additional V-taps on warm side of leads (whereas detailed connection point remains to be clarified) - Action for WP7

‘Quench Detection Scheme and Monitoring Baseline’ – J. Steckert

R5: The responsibilities for proximity equipment must be clarified and synergies exploited between the involved WPs. The development of ‘ELQA measurement ports’ is supported.

- Circuit instrumentation is used for protection + monitoring during operation, but also for ELQA and diagnostic purposes (V-taps and cryo instrumentation routed together out of cold-masses) -> Synergies and coherent approach tbd between WP3, WP6a, WP7

‘QDS Input Patch Panels’ – J. Steckert

‘Current Leads Heating System Design, System Testing and Commissioning’, G. D’Angelo

R6: The IFS systems are to be considered and optimised as a global, integrated system, including flanges, connections on both warm and cold sides as well as cabling and ancillaries

- HL-LHC IFS systems will be located in zones of (very) restricted access and therefore maintenance possibilities. Reliable design of overall system is a must.

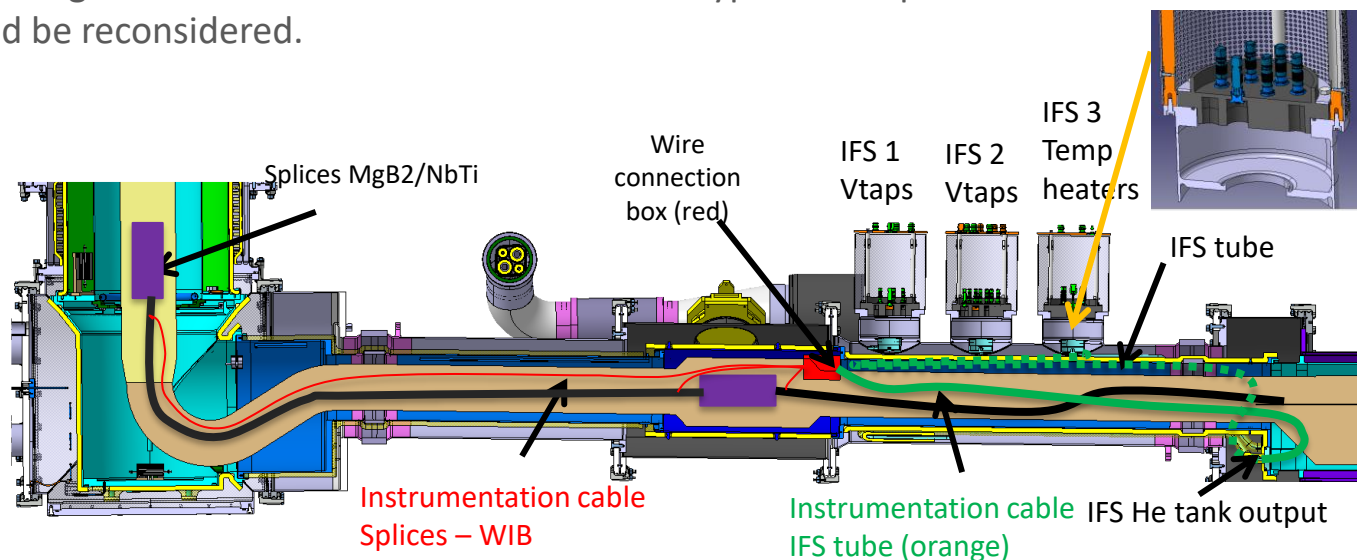
‘Connecting and Integration of the Instrumentation in Magnets, DCM, Cold Powering system’ – H. Prin, Y. Leclercq, C. Barth/J. Fleiter

Review Recommendations 4/10

R7: The detailed design of the instrumentation interconnection box should be addressed rapidly as one of the complex and important items to be integrated

- 190 Vtaps, 40 temp wires and 8 heater wires for DFX initially foreseen (# reduced following R13)
- 100 Vtaps, 40 temp wires and 8 heater wires for DFM initially foreseen (# reduced following R13)

R8: The use of a standard IFS solution for the V-taps (in particular on DFX/M and DFHX/M) should be investigated. The use of the LEMO connector type for temperature sensors on current leads should be reconsidered.



Review Recommendations 5/10

R9: Based on new instrumentation baseline endorsed by the review panel, conduct a final optimization of cover flange types, aiming as well at reducing the number of spare feed-throughs

- Iteration ongoing, aiming at concluding by mid October to allow proceeding with order after IT-4618 -> New baseline proposal in MCF on 13/10
- 2 IFS types proposed (L and S) to optimize number of required vs spare LV- and HV-feedthroughs

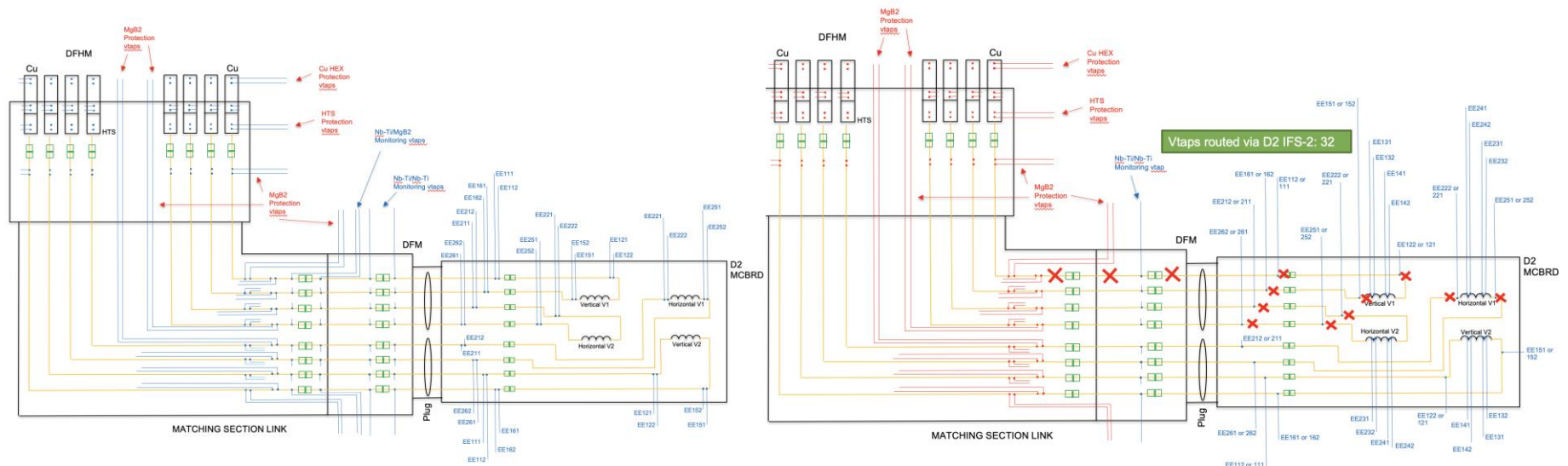
'IFS Box Interfaces and Documentation', G. D'Angelo

R10: A thorough QA process along with the setup of a dedicated test program and planning is mandatory to assure the quality of HL-LHC flanges to match at least that of the LHC flanges

'Connecting and Integration of the Instrumentation in Magnets, DCM, Cold Powering system' – H. Prin, Y. Leclercq, C. Barth/J. Fleiter

Review Recommendations 6/10

R11: The D2 and MCBRD currently foresees redundant V-taps for splice monitoring. The same strategy as for all other circuits should be applied for series (redundant for protection, single for monitoring)



Version 2.0

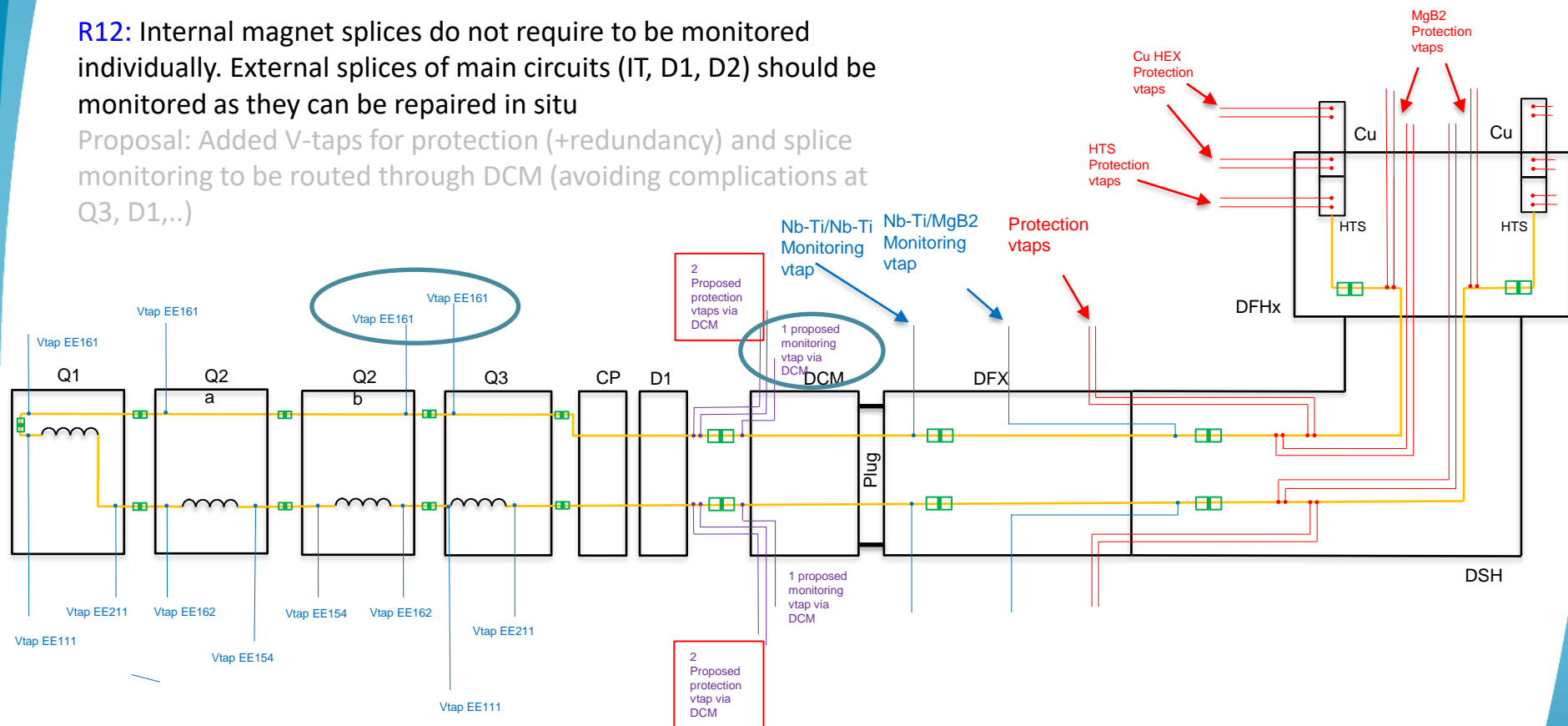
Version 7.0 (including review recommendations)

‘Quench Detection Scheme and Monitoring Baseline’ – J. Steckert

Review Recommendations 7/10

R12: Internal magnet splices do not require to be monitored individually. External splices of main circuits (IT, D1, D2) should be monitored as they can be repaired in situ

Proposal: Added V-taps for protection (+redundancy) and splice monitoring to be routed through DCM (avoiding complications at Q3, D1,..)

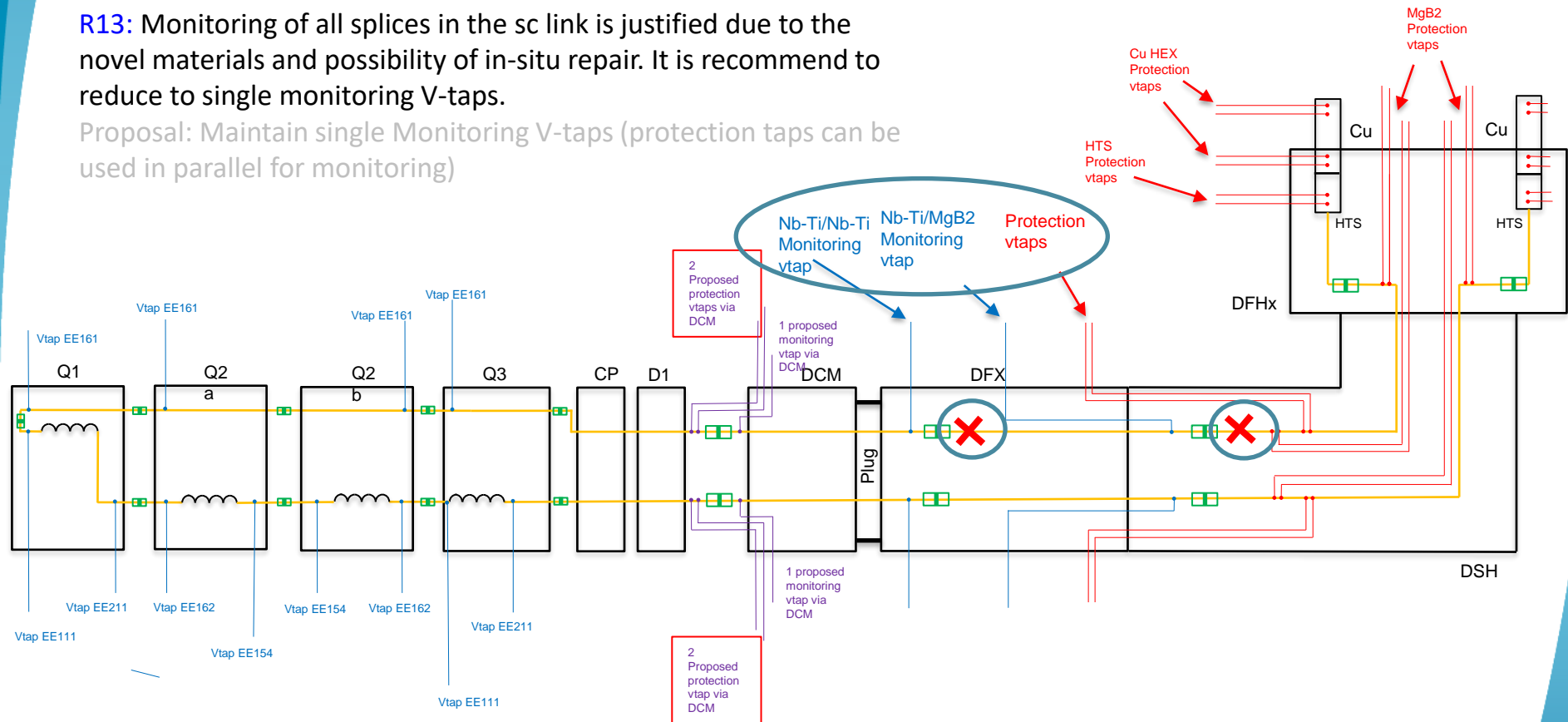


Inner triplet circuit busbar v-taps proposal ver.7 (incl Review Recommendations)

Review Recommendations 8/10

R13: Monitoring of all splices in the sc link is justified due to the novel materials and possibility of in-situ repair. It is recommended to reduce to single monitoring V-taps.

Proposal: Maintain single Monitoring V-taps (protection taps can be used in parallel for monitoring)



Inner triplet circuit busbar v-taps proposal ver.7 (incl Review Recommendation 8/10)

Review Recommendations 9/10

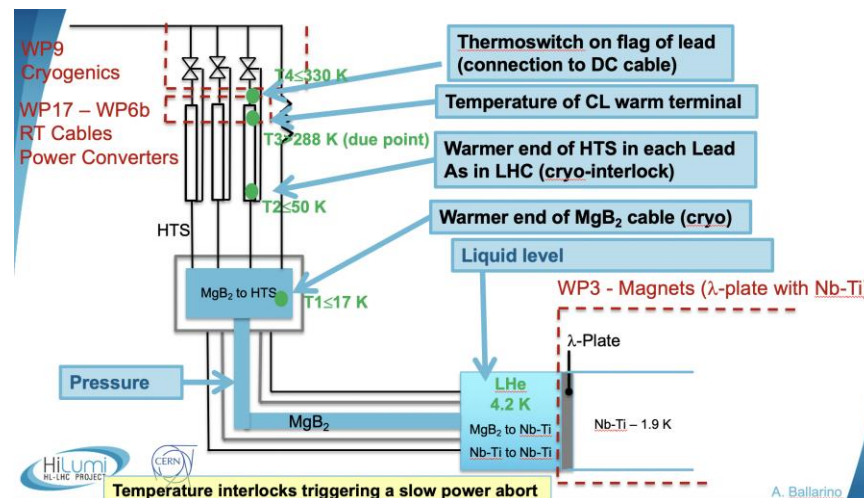
R14: Series magnets shall contain only nominal instrumentation. Additional sensors that may still remain from test setups should be terminated suitably with test and operation requirements

- Example of additional temp sensors used on test benches for MQXF A,...

‘Connecting and Integration of the Instrumentation in Magnets, DCM, Cold Powering system’ – H. Prin, Y. Leclercq, C. Barth/J. Fleiter

R15: Establish and approve an agreed project baseline and protection scheme (including CRYO/SW interlocks) for the machine, among WP6a, WP7 and WP9, aiming at a considerable optimisation of necessary instrumentation

- Temperature regulation (and interlocking) of sc link and of CL in DFHX/M requires cryogenic instrumentation at different levels. Converge on needs for machine configuration after DEMO2 experience.



‘Cryogenic Instrumentation Scheme, System Tests and Commissioning’ – M. Pezzetti

Review Recommendations 10/10

R16: Review and document rationale behind modified choice of instrumentation wires for QH and cryo-heater in view of capillary integration

HL-LHC WP3 uses

- Axon HH1819-LH (ACu= 0.963 mm², 19 filaments) for quench heater wires
Cu cross section 6× that of LHC quench heater wire)
- Axon HH2619-LH for voltage taps
- Axon HT3007 H4-LH for temperature sensors
- Axon HH2019-LH for cryogenic heaters MQXF, D2
Cu cross section 4× that of LHC cryogenic heater wires
- Axon HH2019-LH for cryogenic heaters D1, to be confirmed.







‘Connecting and Integration of the Instrumentation in Magnets’ – H. Prin


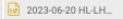
R17: Clarify and document QA procedures for acceptance of instrumentation wires, as they were not presented during the review

‘Connecting and Integration of the Instrumentation in Magnets’ – H. Prin

Timetable 1/2

<https://indico.cern.ch/event/948311/>

08:30 → 08:50	Introduction to the Day and Recall of the Instrumentation Review 2020 and Panel Recommendations	20m	
	Speaker: Markus Zerlauth (CERN)		
09:00 → 09:20	Quench Detection Scheme and Monitoring Baseline	20m	
	<ul style="list-style-type: none">Baseline scheme for quench detection;QDS threshold definition and management;Monitoring baseline.		
	Speaker: Jens Steckert (CERN)		
09:30 → 09:50	System Test and Commissioning of QDS Instrumentation and Monitoring	20m	
	Methodology and tools for QDS instrumentation and monitoring system tests and commissioning.		
	Speaker: Dr Tomasz Podzorny (CERN)		
10:00 → 10:20	Layouts for HL-LHC Quench Detection Instrumentation	20m	
	<ul style="list-style-type: none">Layouts for the HL-LHC quench detection instrumentation and signals.Overview of the instrumentation routing.		
	Speaker: Mr Alvaro Santiago Ferrer (CERN)		
	 Overview of the HL-LHC...  Overview of the HL-LHC...		
10:30 → 10:50	Break and Participants Photo	20m	
10:50 → 11:10	Power Interlock Controller Loops, System Tests and Commissioning	20m	
	<ul style="list-style-type: none">Implementation of PIC loops;Interfaces for HL-LHC;Additions for HL-LHC circuits;System tests and commissioning of the PIC loops and interfaces.		
	Speaker: Alain Antoine (CERN)		
	 MCF_HLLHC_Circuit...  MCF_HLLHC_Circuit...		
11:15 → 11:35	Cryogenic Instrumentation Scheme, System Tests and Commissioning	20m	
	<ul style="list-style-type: none">Scheme required for operation of instrumentation sensors and wiring;Variations of the HL-LHC IT String with respect to the tunnel baseline;Prior tests on sensors to be briefly mentioned;Interlocking methods and communication with other systems;Methodology and tools of system tests and commissioning of the cryogenics instrumentation.		

11:45 → 12:05	Insulation Vacuum Instrumentation Scheme, System Tests and Commissioning	20m	
	<ul style="list-style-type: none">Overview of the insulation vacuum and its instrumentation layout;Variations of the HL-LHC IT String with respect to the tunnel baseline;Prior tests on instrumentation to be briefly mentioned;Interlocking methods and communication with other systems;System tests and commissioning of the vacuum instrumentation.		
	Speaker: Jaime Perez Espinos (CERN)		
12:15 → 12:30	Current Leads Heating System Design, System Testing and Commissioning	15m	
	Overview of the CLHS design, system testing and commissioning.		
	Speaker: Giorgio D'Angelo (CERN)		
12:35 → 14:00	Lunch	1h 25m	
14:00 → 14:20	Connecting and Integration of the Instrumentation in the Magnets	20m	
	<ul style="list-style-type: none">Instrumentation sensors installation and wires connection, routing and testing;IFS flanges overview and validation;Documentation of magnet instrumentation.		
	Speaker: Herve Prin (CERN)		
	 2023-06-20 HL-LHC...  2023-06-20 HL-LHC...		
14:30 → 14:45	Connecting and Integration of the Instrumentation in the DCM	15m	
	<ul style="list-style-type: none">Instrumentation scheme for the DCM;Wires connection, routing and testing;IFS flanges overview and validation;Documentation of DCM instrumentation.		
	Speaker: Yann Leclercq (CERN)		
14:50 → 15:10	Connection and Integration of the Instrumentation in the Cold Powering System	20m	
	<ul style="list-style-type: none">Overview of the cold powering system instrumentation scheme;Wires connection, routing and testing;IFS flanges and splitting modules overview and validation;Documentation of cold powering system instrumentation.		
	Speakers: Dr Christian Barth (CERN), Jerome Fleiter (CERN)		

Timetable 2/2

<https://indico.cern.ch/event/948311/>

15:35 → 15:50	IFS Box Interfaces and Documentation Overview of the IFS box interfaces for HL-LHC and the associated documentation. Speaker: Giorgio D'Angelo (CERN)	15m	📄
15:55 → 16:10	QDS Input Patch Panels Overview of the patch panel and its functionalities and documentation plan. Speaker: Jens Steckert (CERN)	15m	📄
16:15 → 16:30	EIQA Tests for Instrumentation Continuity tests, dielectric tests and other tests linked to instrumentation validation. Speaker: Mateusz Jakub Bednarek (CERN)	15m	📄
16:35 → 16:55	Overview of the System Tests and Commissioning Plan for the HL-LHC IT String <ul style="list-style-type: none">Overview of the planned ISTs and HWC tests within the String Validation Program (SVP).Control, Analysis and Supervision Software for the HL-LHC IT StringMP3 data treatment during HWC Speaker: Samer Yammine (CERN)	20m	📄
17:00 → 17:30	Wrap-up discussion Speaker: All participants	30m	📄

- a lot of excellent (follow-up) work has been done since 2020 to arrive to the instrumentation baseline you will be presented today
- a lot to go through, thanks in advance to speakers for sticking to your allocated time

MANY THANKS TO ALL OF YOU -

**To all speakers, organizers, panel member and participants
for preparing and participating to this important review to
converge on a coherent baseline for the HL-LHC circuit
instrumentation**



Questions?

Charter of 2020 review

- ⑩ to assess the soundness of the instrumentation function and distribution with respect to the requirements given by protection, monitoring and operation, including the hardware commissioning phase
- ⑩ to verify the adequacy of the technical solutions to be implemented by the Work Packages including aspects of long term reliability
- ⑩ to make sure that there is no showstopper for the implementation of the procurement contracts to be signed in the near future
- ⑩ to ascertain that the documentation plan is coherent and is properly updated
- ⑩ to recommend actions on open points or missing aspects

Panel

- ⑩ Markus Zerlauth (Mr Circuit & MCF) - chair
- ⑩ Luca Bottura (MSC GL)
- ⑩ Mirko Pojer (Mr Polarity & MP3)
- ⑩ Andrzej Siemko (MPE GL)
- ⑩ Rob van Weelderen (CRG Expert)
- ⑩ Samer Yammine (EPC) – Scientific Secretary