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(see document ref. EDMS 1271880 for the detailed procedure)

Date: 2017-05-03

ENGINEERING CHANGE REQUEST

WP11: 11 T DIPOLE FULL ASSEMBLY POINT 7

BRIEF DESCRIPTION OF THE PROPOSED CHANGE(S):

The operation with proton and ion beams at both nominal and ultimate intensities requires upgrading the Large Hadron Collider (LHC) collimation system by installing additional collimators in the warm insertions and in the dispersion suppression (DS) regions. To this end, it is foreseen to substitute in the DS region at point 7 two 14.3 m long 8.33 T standard LHC main dipoles (MB) each with an assembly consisting out of a pair of 5.5 m-long 11 T dipoles surrounding a 3.3 m long TCLD collimator. A pair of 5.5 m long 11 T dipoles delivers approximately the same integrated strength of 119 T.m at the nominal operation current of 11.85 kA as one MB. Fine-tuning of the integrated strength is envisaged by using trim power supplies as the 11 T twin-aperture dipoles will operate at 1.9 K in series with the remaining MBs of the sector.

DOCUMENT PREPARED BY:	DOCUMENT TO BE CHECKED BY:	DOCUMENT TO BE APPROVED BY:
Daniel Schoerling **et al.**	**HiLumi-WP11-Integration**	P. Collier (on behalf of LMC) L. Rossi (on behalf of the HL-LHC project)

DOCUMENT SENT FOR INFORMATION TO:

[List of persons to whom the document is sent]

SUMMARY OF THE ACTIONS TO BE UNDERTAKEN:

[List the main actions to be undertaken]

Note: When approved, an Engineering Change Request becomes an Engineering Change Order.

See document ref. EDMS 1271880 for a detailed procedure for handling Engineering Change Requests

1. INTRODUCTION

The operation with proton and ion beams at both nominal and ultimate intensities requires upgrading the Large Hadron Collider (LHC) collimation system by installing additional collimators in the warm insertions and in the dispersion suppression (DS) regions. To this end, it is foreseen to substitute in the DS region at point 7 two 14.3 m long 8.33 T standard LHC main dipoles (MB) each with an assembly consisting out of a pair of 5.5 m-long 11 T dipoles surrounding a 3.3 m long TCLD collimator. A pair of 5.5 m long 11 T dipoles delivers approximately the same integrated strength of 119 T.m at the nominal operation current of 11.85 kA as one MB. Fine-tuning of the integrated strength is envisaged by using trim power supplies, delivering up to 250 A, as the 11 T twin-aperture dipoles will operate at 1.9 K in series with the remaining MBs of the sector.

The proposed change is considered mandatory to be able to ensure a clean disposal of beam halos in the superconducting environment up to the highest envisaged luminosities and beam energies.

The present state of the concerned areas is shown in Figures 1 and 2.

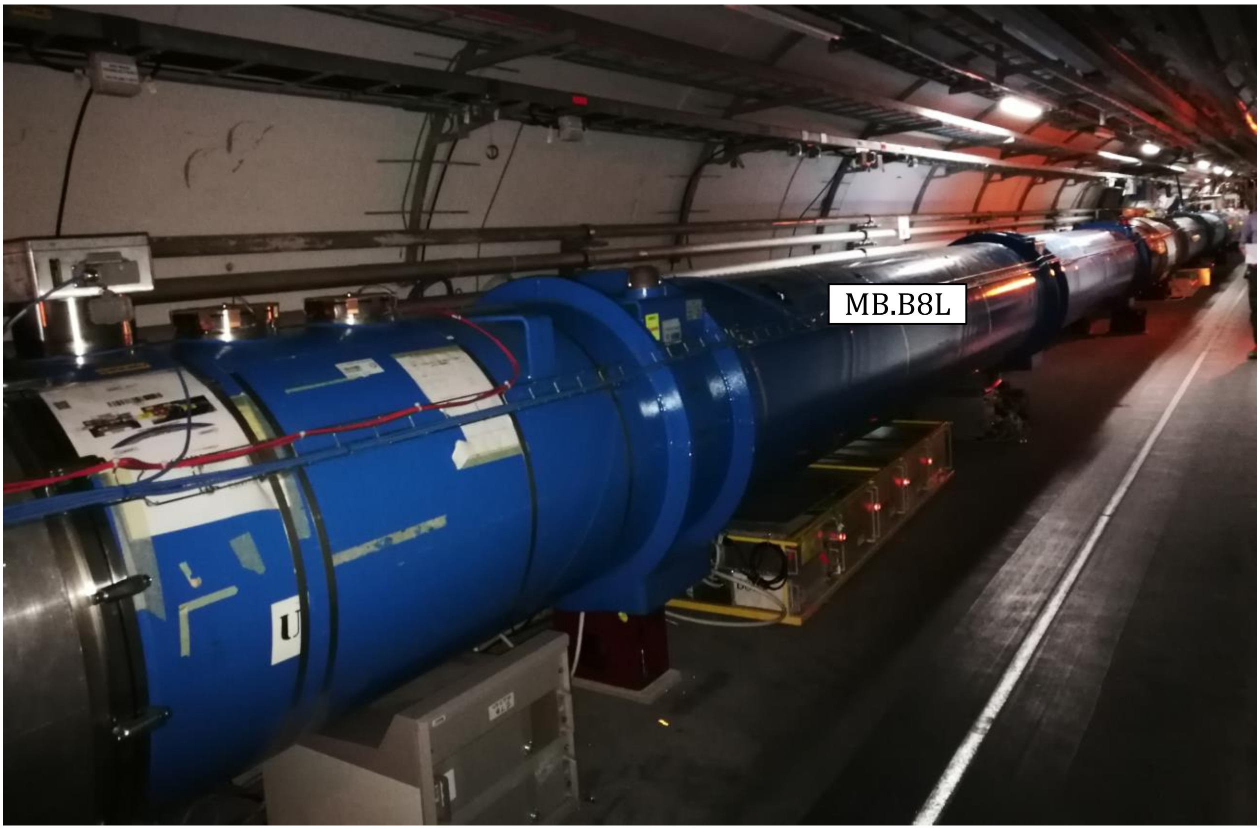

Figure 1 — Picture of area under change, 8.L7 at R72 – present MB.B8L7

Figure 2 — Picture of area under change, 8.R7 at R78 – present MB.B8R7

2. DESCRIPTION

It is foreseen to exchange the following two MBs:

- **MB.B8L7** (LBARA.8L7)
- **MB.B8R7** (LBBRB.8R7)

The magnets are installed at the following positions:

- **MB.B8L7** (LBARA.8L7): distance from IP7: -300.224 m, distance from IP1 (DCUM): 19693.9384 m, half-cell 8.L7, called following **P7 left side**
- **MB.B8R7** (LBBRB.8R7): distance from IP7: 284.564 m, distance from IP1 (DCUM): 20278.7264 m, half-cell 8.L7,, called following **P7 right side**

In detail, the changes comprise the following:

P7 left side

- Removal of the present main dipole **MB.B8L7** (LBARA.8L7, circuit RB.A67)
- Installation of the 11T dipole full assembly at the MB place. The assembly is composed of two dipoles of equal bending strength and shorter magnetic length (Cryo-assembly A and B) and a bypass cryostat in the middle, providing cryogenic and electrical continuity between them.
- After that, installation of a new TCLD collimator between the two magnets, on the beam line 2 (internal beam, or passage side) will follow.

P7 right side

- Removal of the present main dipole **MB.B8R7** (LBBRB.8R7, circuit RB.A78)
- Installation of the 11T dipole full assembly at the MB place: Cryo-assembly A and B, and a bypass cryostat in between.
- After that, installation of a new TCLD collimator between the two magnets, on the beam line 1 (external beam, or QRL side) will follow.

The components to be installed (Table 1), to be kept (Table 2), to be displaced (Table 3) or to be removed (Table 4) are listed below.

2.1 Integration

The integration is described in detail in the document EDMS 1904620.

2.2 Beam dynamics

The bending angle of the beam is kept the same thanks to the same integrated field generated by the pair of 5.5 m-long 11 T dipoles as by an MB. The same integrated field is achieved by powering the 11 T pair in series with the MBs and by using a trim power supply, so no orbit distortions will be generated due to differences in transfer function of the main and the 11 T dipoles.

The field stability is the same, as the 11 T dipoles are connected in series with the MBs, so the current in all magnets is identical during standard operation. It is currently investigated by WP2 if voltage peaks from flux jumps are uncritical for the power converter operation and have any negative effect on the field stability.

The field quality is worse than for the MBs, in particular the sextupole component b_3 is larger. The latest field quality table of the 11 T dipoles can be found in [1]. Beam dynamics studies [2] have shown that the expected field quality is such to leave dynamic aperture essentially unaffected, both at injection and collision energy. For the LHC reset current of 100 A, this specification is met, no modification is required.

The same type and number of spool pieces as currently installed in the MBs will be installed in the 11 T dipoles (LBARA.8L7: MCS and MCDO; LBBRB.8R7: MCS, for symmetry reason a MCDO will be installed but not connected to the circuit).

The sagitta is taken into account by positioning the magnets such that the beam uses most effectively the available mechanical aperture considering that, unlike the main dipoles, the 11 T magnets are straight. The exact position of the magnets will be agreed between WP2, WP11, and WP15 and will be documented through the WP11 Machine Interface Working Group.

2.3 Vacuum modifications

Information to be provided by Pablo Andreu Munoz and Monika Sitko. Information will be made available latest May 18th by TE-VSC.

Table 1: Components to be installed

Equipment name	DCUM [m]	IP7 [m]	Comments
LBHRA+ **LENRA+** **LBHRB** – 11T Full assembly	19693.9384 m 19700.6904 m 19702.8464 m	– 300.224 m – 293.472 m – 291.316 m	Composed of 2 cryoassemblies + 1 bypass cryostat.
2 DYPB double racks	-	-	1 DYPB under LBHRB and 1 DYPB under MB.B9L7. See 2.45 (EDMS 1904620)
1 Power Converter for 11T.8L7	-	-	Installation of a new PC named RYABA01 at RR73. See 2.4.4, (EDMS 1904620)
Water connection for PCs	-	-	For water-cooling of the new PC at RR73. See 2.4.11 (EDMS 1904620)
2 crates for QDS + **trim leads protection** Equipment	-	-	To be installed at RR73. See 2.4.5 (EDMS 1904620)
(**1 half-rack**)	-	-	To be installed at RR73. TBD. See 2.4.5 (EDMS 1904620)
3 additional BLMs			See 2.4.8 (EDMS 1904620)
Exclusion areas at L7	-	-	See 2.4.6 (EDMS 1904620)
LBHRC+ **LENRB+** **LBHRD** – 11T Full assembly	20278.7264 m 20285.4784 m 20287.6344 m	284.564 m 291.316 m 293.472 m	Composed of 2 cryoassemblies + 1 bypass cryostat.
2 DYPB double racks	-	-	1 DYPB under LBHRC and 1 DYPB under MB.A9L7. See 2.45 (EDMS 1904620)
1 Power Converter for 11T.8R7	-	-	Installation of a new PC named RYABA01 at RR77. See 2.4.4 (EDMS 1904620)
Water connection for PCs	-	-	For water cooling of the new PC at RR77. See 2.4.11 (EDMS 1904620)
2 crates for QDS + **trim leads protection** Equipment	-	-	To be installed at RR77. See 2.4.5 (EDMS 1904620)
(**1 half-rack**)	-	-	To be installed at RR77. TBD. See 2.4.5 (EDMS 1904620)
(Metallic structure)	-	-	To be installed at RR77. TBD. See 2.4.5 (EDMS 1904620)
3 additional BLMs at R7	-	-	See 2.4.8 (EDMS 1904620)
Exclusion areas at R7	-	-	See 2.4.6 (EDMS 1904620)

Table 2: Components to be kept

Equipment name	DCUM [m]	IP7 [m]	Comments
VPGFE.8R7 – Pumping group	20282.9930 m	288.83064 m	Placed on the QRL.

Table 3: Components to be displaced

Equipment name	DCUM [m]	IP7 [m]	Comments
VYCTP.A8L7	19694.9034 m	– 299.259 m	Valve control equipment rack placed under present MB.B8L7
QYCGB.8L7	19700.8034 m	– 293.359 m	Cryogenic control rack placed under present MB.B8L7
VPTCB.8R7 – Pump	20282.9930 m	288.83064 m	Placed under present MB.B8R7.
VYCTP.A8R7	20289.1214 m	294.959 m	Valve control equipment rack placed under present MB.B8R7
QYCGB.8R7	20285.4864 m	291.324 m	Cryogenic control rack placed under present MB.B8R7
DYPQ.B8R7	20287.3364 m	293.174 m	Present under MB.B8R7. To be displaced under MB.A8R7
Electrical derivation boxes	-	-	Installed on cable trays. See *EDMS 1904830*

Table 4: Components to be removed

Equipment name	DCUM [m]	IP7 [m]	Comments
LBARA.8L7 (MB.B8L7)	19693.9384 m	– 300.224 m	
DYPB.B8L7	19697.1594 m	– 297.003 m	Protecting present MB.B8L7
RYSA01 rack at RR73	-	-	It will be replaced by the new RYABA01 (11T Power converter)
LBBRB.8R7 (MB.B8R7)	20278.7264 m	284.564 m	
DYPB.B8R7	20281.9464 m	287.784 m	Protecting present MB.B8R7
RYSA01 rack at RR77	-	-	It will be replaced by the new RYABA01 (11T Power converter)

2.4 Cryogenics modifications

Information to be provided by Rob van Weelderen. Information will be made available xxx

2.5 Geometry and alignment modifications/changes

Information to be provided by H. Mainaud. Information will be made available xxx

2.6 Main dipole chain and trim circuit

The modified circuit layout of RB.A67 (with trim circuit **RTB8.L7**) and RB.A78 (with trim circuit **RTB8.R7)** is shown in Figure 3 and 4. A detailed description of the circuits is provided in EDMS 1764166, Section 2.1-2.7. The RB circuit characteristics before and after the change are summarized in Table 5. For the circuit RB.A78 the 11 T dipole full assembly will be placed after the second energy extraction system, creating a little dissymmetry in the RB circuit.

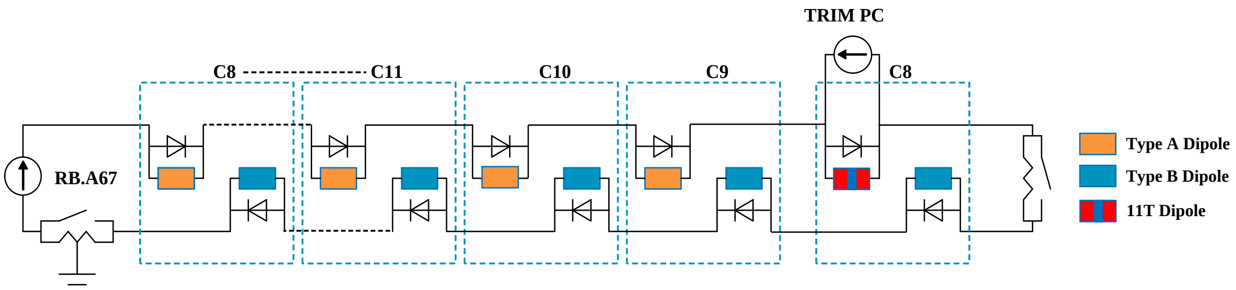

Figure 3. Main dipole circuit RB.A67 configuration for the HL-LHC with the 11T trim power converter.

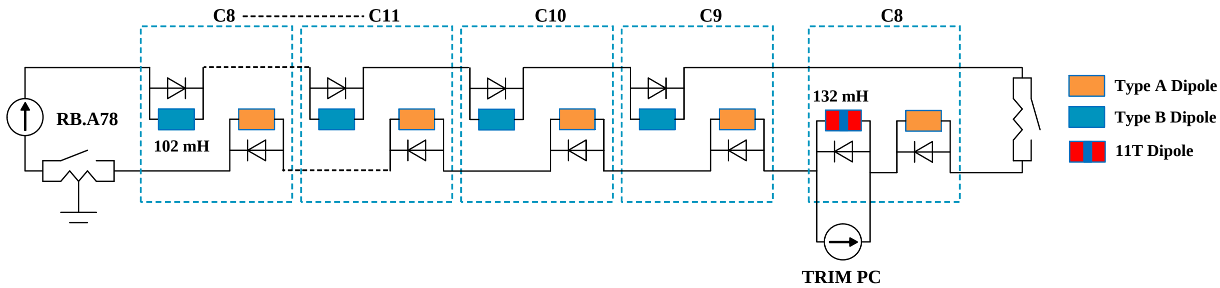

Figure 4. Main dipole circuit RB.A78 configuration for the HL-LHC with the 11 T trim power converter.

Table 5: RB circuit characteristics in the current LHC configuration and after the introduction of 11 T dipole full assembly for circuits RB.A67 and RB.A78 [3].

	Circuit	LHC	HL-LHC
Maximum required PC voltage	RB.A67, RB.A78	171 V	171.6 V
Total Circuit Inductance (L_{TOT})	RB.A67, RB.A78	15.708 H	15.738 H
Circuit time constant (τ)	RB.A67, RB.A78	15700 s	15740 s
Energy extraction Time Constant	RB.A67, RB.A78	112 s	113 s
Maximum Common Voltage of the Trim Circuit in Case of Energy Extraction	RB.A67	420 V	433 V
	RB.A78		425 V
Maximum Common Voltage of the Trim Circuit in Case of Energy Extraction + Earth Fault	RB.A67, RB.A78	910 V	910 V

2.7 11 T dipole circuit protection modifications

2.7.1 Introduction to changes in the quench protection hardware

Due to the installation of the 11T dipole magnets changes in the quench protection hardware, namely in the quench detection system, quench heater power supplies and related ancillary equipment such as interface modules of the corresponding racks and cabling are required. A detailed description of the 11 T dipole circuit (powering and protection) is provided in EDMS 1764166.

Moreover, the new arrangement of current leads for the trim circuit calls for specific quench detectors and current monitoring.

2.7.2 Changes to the quench detection system

2.7.2.1 Hardware

The dipole quench detection crates DQLPU.B8L7 and DQLPU.B8R7, which are installed in protection racks DYPB.B8L7 and DYPB.B8R7, will be dismantled and removed from the LHC tunnel.

For the protection of the 11 T dipoles, newly developed quench detection systems adapted to the specific properties of Nb_3Sn superconducting magnets (uQDS type) will be deployed. In addition, dedicated DAQ systems for the supervision of the quench heater circuits (DQHSU) need to be provided.

2.7.2.2 Cabling

The installation will require the respective set of instrumentation, signal, and hardware trigger and interlock cables. The default QPS interlock cabling traversing the 11 T assembly will need to be modified. All cabling requests are summarized in a "demande d'installation de câbles" (DIC), see impact section.

2.7.2.3 Location

The QDS for the protection of the 11 T dipoles and the associated quench heater circuit supervision unit (DQHSU) will be located in underground areas RR73/RR77 using the remaining free space in QPS protection racks DYPG01=RR73 and DYPG01=RR77.

2.7.2.4 Interlocks

The new QDS will be integrated into the existing QPS internal current loop. While the connection to the powering interlock controller (PIC) will not change, it is foreseen to update the QPS quench loop controllers for circuits RB.A67 and RB.A78 in order to achieve a faster reaction time.

2.7.2.5 Controls

The physical layout of the QPS fieldbus needs to be slightly modified. This concerns segments CBW.IP7.DR7H, CBW.IP7.DL7J, CBW.IP7.DT7A and CBW.IP7.DT7F. The changes concerns only the number and position of field-bus clients; it does not affect any other active equipment like repeater or front-end computers.

The QPS software layer stack and the LHC circuit synoptic need to be updated to be able to interact correctly with the newly installed devices. In particular, this will require the implementation of several new application-programming interfaces (API) and the definition of the corresponding set of signals.

2.7.3 Changes to the nQPS

The replacement of one regular dipole in circuits RB.A67 (half-cell B8L7) and RB.A78 (half-cell B8R7) by new 11 T dipoles will create an exception in the n-QPS system affecting in particular the detection systems for aperture symmetric quenches. In order to preserve the full nQPS functionality, it is necessary to implement a series of modifications.

2.7.3.1 Hardware and location

The DQLPU type S protection crates currently installed in racks DYPB.B8L7 and DYPB.B8R7 need to be relocated to racks DYPB.A9L7 and DYPB.A9R7.

2.7.3.2 Cabling

The nQPS instrumentation and interlock cabling need to be modified accordingly. The details are specified in the respective DIC. It is noteworthy that all cables traversing the 11 T assembly must be routed along one of the cables trays on the tunnel ceiling in order not to interfere with maintenance operations of the collimators.

2.7.3.3 Configuration

The firmware of the nQPS electronics needs to be updated to take into account the new configuration. The respective documentation must be revised as well.

2.7.3.4 Controls

As mentioned before, the QPS software layer stack and the LHC circuit synoptic need to be updated with respect to the new nQPS configuration.

2.7.4 Changes to the rack containing the heater discharge units

The 11 T cryo-assemblies are going to replace magnets MBA.B8L7 (circuit RB.A67) and MBB.B8R7 (circuit RB.A78). The protection of the new 11 T dipoles will require an increase of quench heater circuits and therefore an increase in the number of heater power supplies. Precisely, there will be sixteen heater power supplies per 11 T cryo-assembly. Moreover, the reduced room below the cryostats due to the different systems installed underneath them acts as a significant constraint.
As a result, one has to deal with the design of a new rack type upgrading the current DYPB rack, and the upgrade of the DQLIM to be installed in the new racks. In addition to this, the DQHDS units must be upgraded to be compatible with both the faster triggering times and the availability requested by the protection of the 11T dipoles themselves.

2.7.4.1 Hardware and implications

DQHDS firing speed

The response time of the DQHDS units in firing must be reduced to a maximum of 1 ms. In order to achieve this option, TE-MPE-EE is studying several options: (1) the optimization of the current version using other relays, (2) the use of relays in parallel with optocouplers, and (3) the use of MOSFETs instead of relays

Redundancy configurations

Since the full 11T magnet cannot withstand the loss of more than two out of sixteen DQHDS units, powering redundancy must be incorporated. Therefore, several alternatives have been studied, and the most preferable option is to power each rack with four F3 and four F4 AC inputs together with eight circuit breakers per rack. In addition, each DQHDS

unit will be modified in such a way that its trigger circuit will have a redundant powering from F3 and F4. However, the capacitors will still be energized by either F3 or F4.
The possibility of monitoring the powering of the capacitors is presently under study.

Remarks

Since the quench detectors will be located in the RRs, the DQLIM design needs to take this into account. Also, it will be optimized in order to be in accordance with the new rack design.

2.7.4.2 Location

The racks will be placed around P7 of LHC. For the right side, there will be a rack underneath the 11 T cryostat before the collimator (LBHRC) from the IP, and another one under MB.B9L7 (see the grey boxes in Fig. 5). For the case of the left side, one rack will be also installed below the 11 T dipole cryostat before the collimator (LBHRB) from the IP, and another rack under MB.A9R7. There will be a total of four racks installed in the machine, however one more unit (to be considered as spare) will be manufactured.

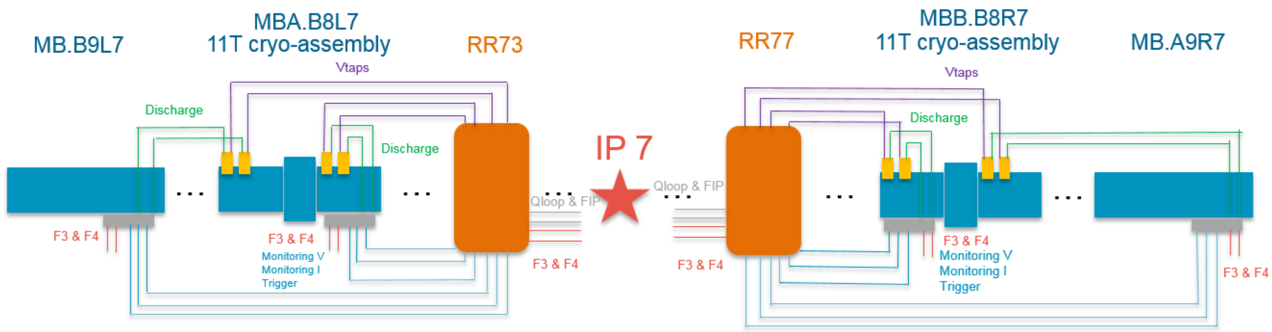

Figure 5. Location of the new DYPB for the 11T dipoles.

2.7.5 Changes to Powering Interlock System (PIC)

The Powering Interlock System (PIC) is designed to ensure the permission for powering the different electrical circuits with superconducting magnets installed around the LHC. It interfaces power converters, quench detection systems, technical services (AUG, UPS, cryogenics, etc.) and is a client of the Beam Interlock System (BIS) in order to request a beam dump when necessary. The two new 11 T superconducting magnets will be connected in series with the RB.67 and RB.78 main dipole circuits requiring a trim power converter each, which have to be connected to the PIC. The interlock requirements of the 11 T circuit are summarized in Table 6 [3].

Table 6: Interlock requirements

Interlock case	**PIC Action on RB Circuit**	**PIC Action on Trim Circuit**	**Beam Dump**
Quench in RB circuit	Fast Power Abort	Fast Power Abort	Yes
Powering Failure in RB Circuit	Slow power Abort	No action	Yes
Powering Failure in Trim Circuit	No action	Slow Power Abort	Yes
Switch opening request by RB PC	Fast Power Abort	Fast Power Abort	Yes

Cryo-failure	Slow Power Abort	Slow Power Abort	Yes

The LHC main dipole circuits have the feature of being interfaced with the two adjacent PIC of the arcs (even and odd), sharing the same quench loop, and their power converters located on the even side. The new 11T Trim power converters will be located at the odd side of the arc (RR73 and RR77) and connected to the corresponding PIC as independent circuits.
The hardware interfaces of the PIC are standardized and are defined according to the type of electrical circuit. There are currently 6 different listed types (A, B1, B2, C, D) [5] grouped into 4 different patch panels (CIPPA, CIPPB, CIPPC, CIPPS). Since the configuration of a PIC is generic, there are some hardware interfaces that remain unused. For the two PIC in P7, the current interface configuration contains a free "B1 type" hardware interface on the CIPPS patch panel, which will be used to connect the new 11T Trim power converters. The peculiarity of these new circuits will be to have no connection with QPS, which will require creating a virtual "quench loop" internally to the PIC. This will be done using one of the available loop current sources of the mezzanine daughter board (CIPI) of the patch panel CIPPC.

The proposed implementation will fulfill the requirements summarized in Table 6:

- If a quench in the RB circuit or a EE switch opening occurs, a general fast power abort action on both PIC will be taken through the global protection mechanism [6].
- If a powering failure occurs, a slow power abort action will be taken only on the faulty circuit (RB or Trim).
- A cryo failure will cause a slow power abort of both RB and Trim circuit because the same status of the Cryo interlock is sent from a unique Cryo PLC to both arc PIC.

2.7.6 Protection of trim current leads

The trim circuit (RTB8) for each of the 11 T dipoles will be powered through a set of 2 x 2 resistive current leads. The protection of the four trim leads will require monitoring of the lead voltages and currents. These signals will be evaluated by a standard HL-LHC quench detection system (uQDS), which initiates the necessary action e.g. a fast power abort of the concerned trim circuit.

2.7.6.1 Hardware

The additional quench detection crates need to be installed inside RR73/RR77 (ground floor). Unfortunately there is not enough space to integrate these units in protection racks DYPG01=RR73 and DYPG01=RR77. For the additional space, the adjacent half rack DYPIB01 (shared with the PIC half rack CYCIP01) could be used.
For the measurement of the lead currents, current sensors of the Hall type and clamped to the power cables will be installed in RR73 and RR77.

2.7.6.2 Cabling

The additional cabling concerns mainly the instrumentation cables linking the current lead feed through box with the quench detection crates; those cables are listed in the DIC mentioned above. In addition, there will be the signal cables for the current sensors and the interlock cables, which are local to RR73/RR77.

2.7.6.3 Interlocks

The new QDS for the trim current leads needs to be integrated into the hardwired interlock loop for the trim circuits.

2.7.6.4 Controls

As for the changes above, the QPS software layer stack and the LHC circuit synoptic need to be updated accordingly. In this case, this concerns as well the configuration of the PIC.

2.7.7 Cabling

A rather large number of cables will be added and modified due to the replacement of the current dipoles MBA.B8L7 and MBB.B8R7 for the new 11T dipole cryo-assemblies.

Detailed DICs (reference RQF0908671, Plan ID : 10823 and RQF0888406) have already been prepared and sent to EN-EL. Accordingly, all the cabling concerning the new racks (discharge, monitoring, triggering, etc) needs to be installed.

The nQPS crates below the dipoles located in B8 (both sides), will be moved to a position below A9 and various cables will be re-installed.

Moreover, there is today a DYPQ rack located under MB.B8R7 that will be moved under MB.A8R7. This requires consequently new cabling between the quadrupole cryostat and the new position of the rack. See Fig. 6.

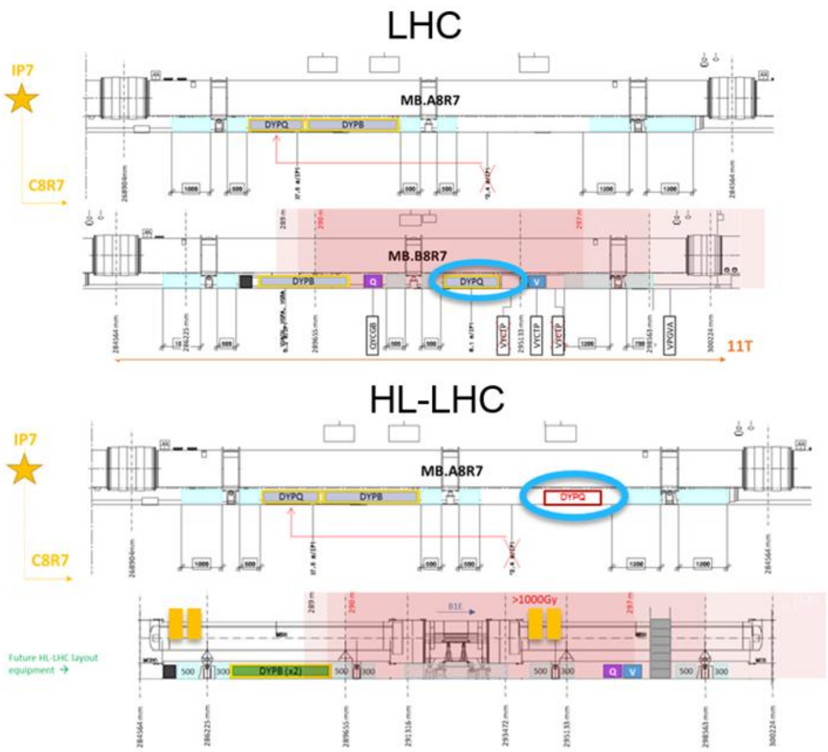

Figure 6. Relocation of the DYPQ that needs to be moved due to the high radiation doses.

3. IMPACT

3.1 IMPACT ON ITEMS/SYSTEMS

LHC Layout	LHCLSS__0029 - IR7 LEFT, CELLS C8.L7 TO C11.L7 LHCLSS__0030 - IR7 RIGHT, CELLS C8.R7 TO C11.R7
Updated layout drawings	LHCLSSSH__0013 - IR7 LEFT, CELLS C8.L7 TO C11.L7 LHCLSSSH__0014 - IR7 RIGHT, CELLS C8.R7 TO C11.R7
Main dipole chain	Circuits RB.A67 and RB.A78 will be modified. Table 5 provides a comparison of the parameters before and after the change.
MP3	Hardware commissioning powering tests procedures have to be updated and established

3.2 IMPACT ON UTILITIES AND SERVICES

Raw water:	No impact
Demineralized water:	Water pipes (water circuit already existing in RR73 and RR77, but not near the PC). Therefore, pipes should be added to cool each rack with at least 3 l/min. The expected ΔT=x K {TO BE DISCUSSED}
Compressed air:	No impact
Electricity, cable pulling (power, signal, optical fibres…):	AC cabling for trim power converters (3P+N 16 Arms (4mm^2).) DC cabling for connection of trim power supplies (WP17)
DEC/DIC:	TE-MPE: DICs (reference RQF0908671, Plan ID : 10823 and RQF0888406) WFIP cabling for trim power converters: DIC? MORE DICs?
Racks (name and location):	TE-MPE list of all required racks, name and location Power converter for trim circuit in RR73 and RR77, one rack per power converter? More racks required: BLM, Instrumentation? The racks to be installed, displaced and removed are listed in Table 1-4.
Vacuum (bake outs, sectorisation…):	Beam screen in the 11 T magnets and TCLD collimator has to be replaced: IMPACT Bake-out of the TCLD collimator has an impact on the 11 T dipole magnet (strategy under discussion) Sectorisation?
Special transport/ handling:	The equipment listed in Tables 1, 2, and 3 needs to be transported and handled in the tunnel and on ground
Temporary storage of conventional/radioactive components:	The de-installed equipment (Table 4) may be radioactive and has to be stored. In particular the two main bending magnets: MB.B8L7 and MB.B8R7
Alignment and positioning:	Marking the new slot and alignment after installation
Scaffolding:	No impact
Controls:	TE-MPE TE-EPC Timber

	Cryogenics Vacuum The physical layout of the QPS fieldbus needs to be slightly modified. This concerns segments CBW.IP7.DR7H, CBW.IP7.DL7J, CBW.IP7.DT7A and CBW.IP7.DT7F. The changes concerns only the number and position of field-bus clients; it does not affect any other active equipment like repeater or front-end computers.
GSM/WIFI networks:	GSM should be available during the activity as communication means complementary to the red phones in case of emergency.
Cryogenics:	To be completed
Contractor(s):	No
Surface building(s):	No impact
Others:	

4. IMPACT ON COST, SCHEDULE AND PERFORMANCE

4.1 IMPACT ON COST

Detailed breakdown of the change cost:	Frederic Savary
Budget code:	Frederic Savary

4.2 IMPACT ON SCHEDULE

This table will be discussed on June 5th: https://indico.cern.ch/event/727279/

Proposed installation schedule:	**P7 right side**: October 2019 (readiness for installation), +4.5 months (installation of the deliverables of WP11), +1 month complete installation with collimator **P7 left side**: February 2020 (readiness for installation) , +4.5 months (installation of the deliverables of WP11), +1 month complete installation with collimator
Proposed test schedule (if applicable):	The test schedule is included in the above presented installation schedule
Estimated duration:	Not applicable
Urgency:	Not applicable
Flexibility of scheduling:	In case the magnets are ready for installation before the planned date, the planning may allow installing them earlier. In case the magnets are ready for installation after the planned date, LS2 has to be extended according to the current baseline planning. A study how to compress the installation time is currently ongoing to gain some contingency in the planning.

4.3 IMPACT ON PERFORMANCE

Mechanical aperture:	No impact on beam aperture is expected by the installation of the 11 T dipoles (see Section 2.2).
Impedance:	To be completed with the impedance team (BE-ABP, BE-RF). Check the longitudinal and transverse contributions to minimise beam induced heating and instabilities. In case of potential impedance issues asses the need of: damping resistors (SPS), ferrites (SPS or LHC), coating, tapered transitions… Consider the full integration of the device in the existing beam line (transitions, bellows and insulation).] B. Salvant
Optics/MAD-X	No negative impact on beam dynamics is expected (see Section 2.2). The LHC reference MAD-X file needs to be updated and the exact positioning of magnets has to be agreed on.
Electron cloud (NEG coating, solenoid…)	No e-cloud effect is expected? G. Iadarola
Insulation (enamelled flange, grounding…)	[To be completed with BE-RF. Detail insulation requirements. Consider the EMC/EMI aspects of the installed device.]
Vacuum performance:	[To be completed with TE-VSC.]
Machine protection	Daniel Wollmann
Cryogenics	Rob van Weelderen
Others:	

5. IMPACT ON OPERATIONAL SAFETY

5.1 ÉLÉMENT(S) IMPORTANT(S) DE SECURITÉ

Requirement	Yes	No	Comments
EIS-Access		X	
EIS-Beam		X	
EIS-Machine		X	

5.2 OTHER OPERATIONAL SAFETY ASPECTS

Have new hazards been created or changed?	The 11 T dipole magnet is a pressurized equipment. The 11 T cold mass will be filled with liquid helium.
Could the change affect existing risk control measures?	The hazard is of the same kind and of the same order of magnitude as for the currently installed device.
What risk controls have to be put in place?	To mitigate the risk of overpressure, safety relief devices are installed The conformity of the pressurized equipment is being addressed by HSE acting as notified body.

	HSE will deliver the safety clearance for operation and assess the conformity to the European PED The main dipole circuit are in the interlock for powering phase II, the trims will be also connected to the PIC, if necessary The cool down permits will be delivered to allow the safe cool-down of the sectors 67 and 78.
Safety documentation to update after the modification	All the safety documentation asked by the notified body will be archived in EDMS: https://edms.cern.ch/project/CERN-0000183369
Define the need for training or information after the change	No change required for the LHC online training course. The teams intervening on the new equipment need to be trained.

6. WORKSITE SAFETY

6.1 ORGANISATION

Requirement	Yes	No	Comments
IMPACT – VIC:	X		WP11 or TE-MSC (to be confirmed by Sandrine) needs to trigger the VIC and create the IMPACT
Operational radiation protection (surveys, DIMR…):	X		Christophe Tromel or Cristina Adorisio from HSE-RP. Check with your RSSO.
Radioactive storage of material:	X		To be discussed: Christophe Tromel or Cristina Adorisio from HSE-RP. Check with your RSSO.
Radioactive waste:	X		Volume of radioactive waste will be generated by the worksite itself and will be very limited in volume The removed magnets will be kept as spare
Non-radioactive waste:	X		Very limited
Fire risk/permit (IS41) (welding, grinding…):	X		The fire permits and the fire mitigation procedures will be defined during the VIC
Alarms deactivation/activation (IS37):	X		The alarms deactivation or activation will be defined during the VIC
Others:	X		This task will be subjected to the WPA coordinated by the LHC coordination team in the framework of the LS2 activities

6.2 REGULATORY TESTS

Requirement	Yes	No	Responsible Group	Comments
Pressure/leak tests:	X		HSE	Work is organized by PSO and was delegated to Arnaud Foussat; PED to be followed
Electrical tests:	X		Felix	Standard procedures as agreed on in MCF have to be followed (to be checked with Felix)
Others:	X		BE-DSO	PIC will be validated during the DSO tests

6.3 PARTICULAR RISKS

Requirement	Yes	No	Comments
Hazardous substances (chemicals, gas, asbestos…):		X	
Work at height:	X		To be determined during the VIC
Confined space working:		X	
Noise:		X	
Cryogenic risks:		X	The sector will be warmed up and emptied before installation
Industrial X-ray (*tirs radio*):	X		The weldings may be inspected by X-rays (to be confirmed)
Ionizing radiation risks (radioactive components):	X		All removed equipment and waste will be tracked by TREC
Others:			

7. FOLLOW-UP OF ACTIONS BY THE TECHNICAL COORDINATION

Action	Done	Date	Comments
Carry out site activities:			
Carry out tests:			
Update layout drawings:			
Update equipment drawings:			
Update layout database:			
Update naming database:			
Update optics (MADX)			
Update procedures for maintenance and operations			
Update Safety File according to EDMS document 1177755:			
Others:			

8. REFERENCES

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[3] G. Apollinari et al., High-Luminosity Large Hadron Collider (HL-LHC), Technical Design Report V. 0.1, CERN-2017-007-M.

[4] S. Izquierdo Bermudez, S. Yammine, R. Denz, F. Menendez Camara, A. Antoine and I. Romera Ramirez: "11T dipole Circuit - Powering and protection", Engineering Specification LHC-MBH-ES-0001, EDMS No. 1764166

[5] B.Puccio, R. Schmidt, M. Zerlauth: "The Hardware Interfaces Between Powering Interlock System, Power Converters And Quench Protection System", Engineering Specification LHC-D-ES-0003 rev 3.0, EDMS No. 368927

[6] "Powering Interlock Controller Software Functionality", Functional Specification ATS-CIP-ES-0001 rev 1.0, EDMS No. 1360776