WP11 technical machine interfaces working group,
meeting # 1

Daniel Schoerling
On behalf of the machine interface working group

CERN, 24th of April 2018

Mandate

- The WP11 technical interfaces working group meeting is the meeting where all aspects related to interfaces of WP11's deliverables are discussed
- If an issue concerning the WP11 interfaces is identified it will be escalated to the proper project bodies (HL-TCC, HL-PSM, MCF, HL-LHC integration meeting), groups, WP leaders or the project management
- The aim of this meeting is to ensure the compatibility of technical interfaces of WP11 and their readiness for operation
- After first successful operation of the deliverables of WP11 the work is considered completed
- Subjects in the agenda are defined in close collaboration with the relevant WPs and the other meetings (HL-TCC, HL-PSM, MCF, MP3, HL-LHC integration meeting)
- Prepare two HL-LHC Interface Specifications (IS): WP11 Point 7 11 T Dipole and WP11 Point2 Connection Cryostat Full Assembly
- Establish two Engineering Change Requests (ECR): WP11 Point 7 11 T Dipole and WP11 Point2 Connection Cryostat Full Assembly
- The outline, content and progress of the ECRs is discussed in the meeting
- The meetings will take place bi-weekly (Tuesdays, *3:15-5:15 pm*, odd weeks)

Interfaces with other working groups

- This working group shall not carry out work already done elsewhere. For example in the MCF, HL-LHC integration meeting, MP3, etc.

WP11 interfaces

- Beam dynamics [WP2], M. Giovannozzi
- Collimation scenarios [WP5], S. Redaelli
- Mechanical 3D model, A. Bertarelli, L. Gentini, A. Ghezzo, Christophe Yves Mucher
- Integration model, Maria Amparo Gonzalez de la Aleja Cabana
- Cryogenics [WP9], R. van Weelderen
- Vacuum [WP12], M. Sitko, V. Baglin, G. Riddone
- Geometry and alignment [WP15], D. Missiaen, H. Mainaud-Durand
- Powering and trim circuit [WP6B], H. Thiesen, S. Yammine, M. Martino
- Trim current leads, A. Ballarino
- Machine protection, D. Wollmann
- QPS, R. Denz, D. Wollmann
- Software, M. Zerlauth, D. Wollmann
- MCF-ELQA and voltage withstand levels, F. Rodriguez Mateos
- MP3-LHC magnet circuits, powering and performance panel, A. Verweij
- Compliance to pressure equipment directive, A. Foussat
- Integration, (de-)installation [WP15], P. Fessia, M. Modena, Maria Amparo Gonzalez de la Aleja Cabana
- Cryo-assembly, D. Ramos
- Cold mass assembly, H. Prin
- Operation, M. Pojer
- Interconnections, J.P. Tock, H. Prin, N Bourcey
- HL-LHC Project Safety Officer (T. Otto)
- HSE (Carlos Arregui Rementeria, Jose Gascon)
- Cryo-magnet coordinator and Magnet Evaluation Board (MEB) (S. Le Naour)

Interfaces not discussed in the next slides:

- Transport, C. Bertone
- Energy deposition, A. Lechner
- Beam-loss monitors, A. Lechner
- DC electrical distribution, J.C. Guillaume
- 11 T electrical engineering, A. Foussat

- Storage of signals: TIMBER

List of participants (*HI-LUMI-LHC-WP11-Interfaces*)

- Vincent Baglin
- Marta Bajko
- Amalia Ballarino
- Alessandro Bertarelli
- Caterina Bertone
- Robin Betemps
- Nicolas Bourcey
- Giuseppe Bregliozzi
- Juan Carlos Perez
- Francesco Cerutti
- Gijs De Rijk
- Reiner Denz
- Beniamino Di Girolamo
- Sandrine Le Naour
- Delio Duarte Ramos
- Paolo Fessia
- Lucio Fiscarelli
- Jean-Frederic Fuchs
- Jean-Christophe Garnier
- Javier Gascon
- Massimo Giovannozzi
- Ludovic Grand-Clement
- Jean-Claude Guillaume
- Carnita Hervet
- Susana Izquierdo Bermudez
- Friedrich Lackner
- Anton Lechner
- Helene Mainaud-Durand
- Michele Martino
- Matthias Mentink
- Dominique Missiaen
- Michele Modena
- Thomas Otto
- Arnaud Pascal Foussat
- Mirko Pojer
- Herve Prin
- Rosario Principe
- Stefano Redaelli
- Carlos Arregui Rementeria
- Germana Riddone
- Felix Rodriguez Mateos
- Thomas Sahner
- Frederic Savary
- Daniel Schoerling
- Javier Serrano
- Monika Sitko
- Jens Steckert
- Hugues Thiesen
- Jean-Philippe Tock
- Ezio Todesco
- Rob Van Weelderen
- Arjan Verweij
- Gerard Willering
- Daniel Wollmann
- Samer Yammine
- Markus Zerlauth

Beam dynamics

- Integrated field? Trim was discussed and finalized
- Field stability? Flux jumps?
- Field quality? Studied, non-critical
- Sagitta? Dealt with in different meetings: decision will be reported in this meeting by Massimo

Vacuum 1/3

Cold-warm transitions

- Prototypes: 1 short +1 long DONE
- Pre-series: 2 short + 2 long IN PRODUCTION
- Series: 5 short +5 long PENDING

Standard beam screen bellows:

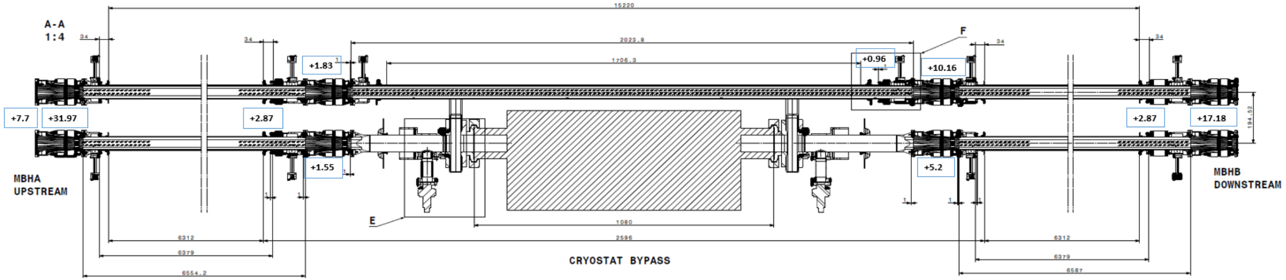
- 4x4 needed + spares

PIM MB-MB and MB-SSS version:

- 8x4 needed + spares

Short beam screen bellows:

- 30 pieces ordered at Skodock, delivery: week 21 (4-8.06)
- 10 pieces ordered at Kompaflex, delivery : week 26 (25-29.06)



Vacuum 2/3

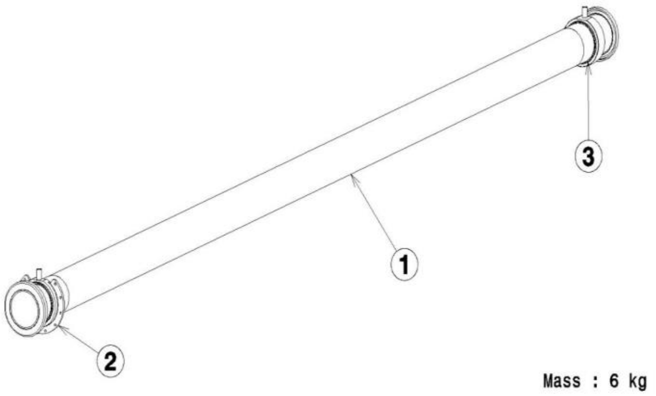
Copper Cold Line:

- Prototype: DONE
- Pre-series: 2 elements IN PRODUCTION
- Series: 6 elements IN PRODUCTION

Various BS types [LHC arc type but different lengths]

- LEN (7 x~ 2020 mm) – 3 different types (+ spares)
- LEP (12 x~ 5300 mm) – 8 different types (+ spares)
- LBH (12 x~ 6600 mm) – 4 different types (+ spares)

Sector Valves and TCLD instrumentation



Detailed planning on EDMS 1889343

INPUT ON PRIORITY NEEDS according to assembly sequence

Vacuum 3/3

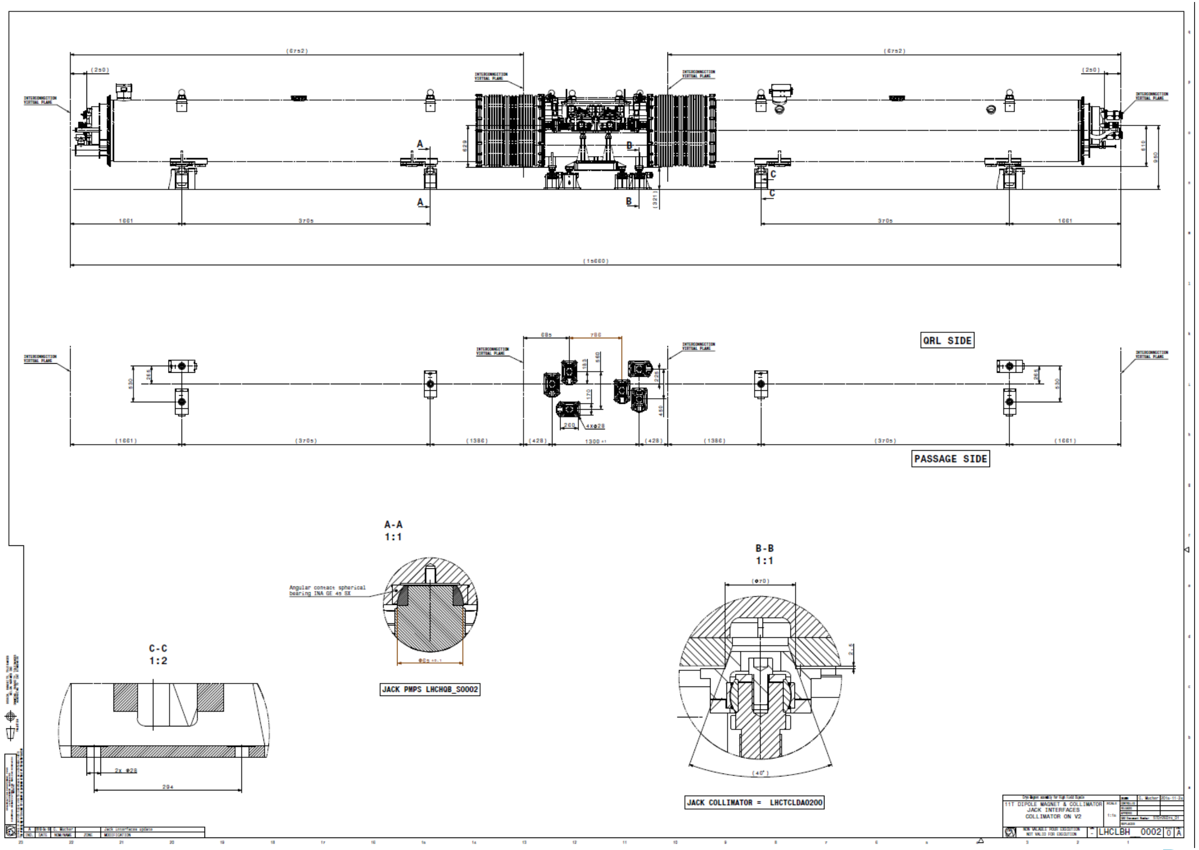
- Baking out equipment for TCLD collimator is listed in EDMS 1903950
- Baking out (~300°C) can be done while the magnet is at 1.9 K, floating (~80 K) or at ambient temperature?
- Preferred at lowest temperature: Possible? Magnet has to be emptied (He) and temperature is floating for 3 days → To be discussed
- What is the temperature seen by the adjacent 11 T dipole coil during bake-out?
- What is the impact on people safety?

→ Recommendation will be given by the HL-LHC PSO (Thomas Otto)

Collimation scenarios

- TCLD collimator: EDMS 1903950, p. 31
- Interfaces with cryo-magnet defined in “integration with collimator and general integration model”
- Alignment : see alignment slides
- Mock-up unit: installation foreseen in SM-I2? At this stage an integration study is foreseen. Luca Gentini is the responsible engineer for this activity. Schedule?
- Discussion on-going what to do for future tests to understand the impact of the bake-out on the temperature of the vacuum chamber in the magnet $\rightarrow$ See slides on interfaces with vacuum
- Do we need to do a bake-out test at SM18?

Integration with collimator and general integration model



Cryogenics

WP 9 provides the following functional input to the cryo-magnet team (March 14th). Considering:

- the "short- side" of the cryogenic bypass that has the least amount of magnets between it and the next hydraulic plug at the quadrupole interconnect
- that we use the 300 mbar pressure reserve as allowable extra pressure drop due to the introduction of the cryogenic bypass (see Rob’s presentation at the cryostat working group)
- that with 12 x DN200 valves we normally take care of the discharge fixed at 30 kg/s at 90 K. Should those 12 be put on the "short-side" we would be independent of the cryogenic bypass hydraulics (but 12 is a lot!)
- that the mass-flow that has to pass through the bypass increases from 0 kg/s (with number of DN200 valves N200 =12) to 30 kg/s for N200 = 0
- that we should not exceed the sound velocity at the cryogenic bypass restrictive passages (such as not to choke the flow).
- only the various pressure drops through the supports (worst obstructions) and the pipe sections of the bypass-cryostat's biggest connection (so we get a bit of margin via the 2 parallel connections, which are quite full however).

Conclusion: We need a minimum of N200 > 7 on the "short-side" of the cryogenic bypass!

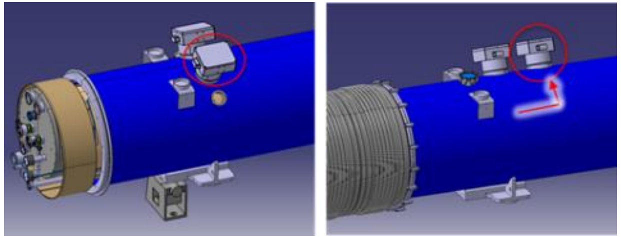
Aim: 8 x DN200, to be distributed over the cryostats on the "short-side" of the cryogenic bypass of which one should not be spring loaded and 7 should be spring loaded, the first DN200 valve next to the by-pass should also not be spring loaded -> Defines the exclusion area

- Instrumentation as for standard dipole, but double the number -> feed-through and cards need to be available and installed

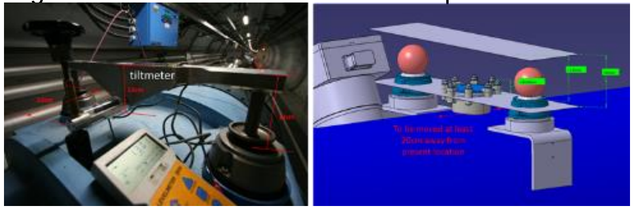
Delio has sent a first diagram to Rob, the work is on-going

Geometry and alignment 1/3

- Few changes compared to main dipoles in the LHC
- IFS box position has been changed to allow for alignment: **impact on spare policy: magnet cannot be turned**
- The DN100 flanges on 11T cryostats have been placed between survey targets, preventing the standard LHC tool for taking roll measurements from being placed on such targets
- The solution agreed between Survey team and WP11 was to add an additional reference on the 11T magnets for the roll measurement, defined by a machined cylinder which must satisfy the following conditions:
  - The cylinder must be fixed above the double jack position.
  - The cylinder will be added at CERN (WP11 agreed to this).
  - The cylinder must be in place before the fiducialisation measurement.
  - This cylinder will be added on the plate that supports the survey socket (on the transport side and on the double jack side). The detailed solution, satisfying SU requirements, will be provided by WP11.
- Feet need to be turned around for consistency with other dipoles ->cryostat already produced, turning might still be possilbe

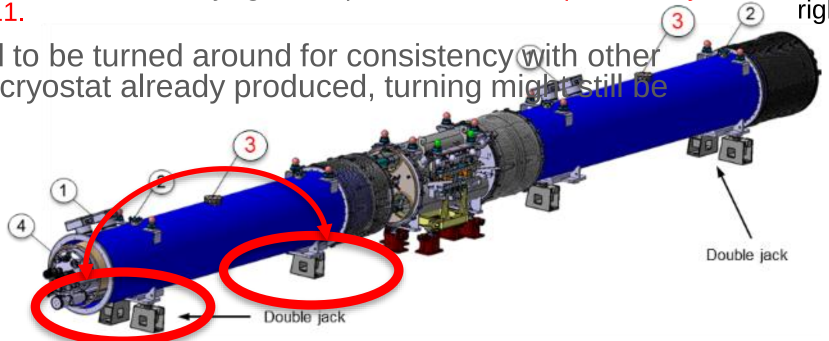


Left: the initial design pointing out the IFS box that was causing an interference with space needed for the alignment of the LHC machine. Right the solution found with the new position of the IFS box.



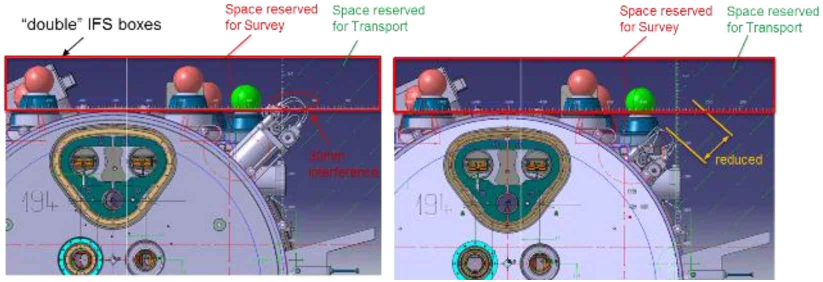
On the left, standard LHC tool for measuring roll angle. On the right, tool interfering with the DN100.

Cylinder placed on the plate supporting the survey socket



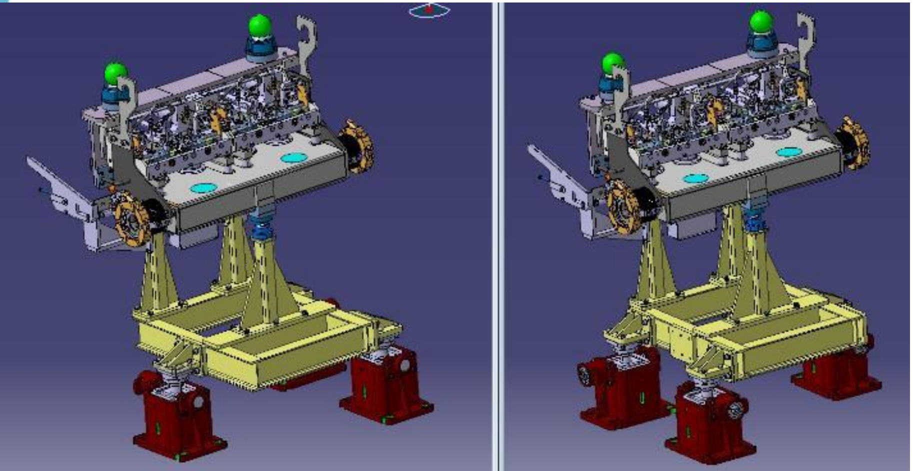
Geometry and alignment 2/3, interface to WP11

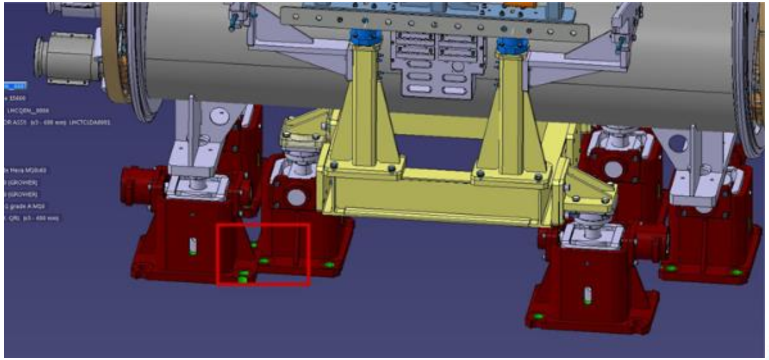
- The current situation is not sufficient, not easy to manipulate
- Activation for realignment after couple of years?
- Position of alignment targets to be clarified
- Sequence of alignment: first magnets are aligned, second collimator and cryostat is aligned



Interference between alignment and vacuum sector valves. On the left: extended valve. On the right: compact valve.

Two different arrangement of jacks. On the left: TCLD.L7, L2 and R2. On the right: TCLD.R7





Interference found between TCLD jacks and Bypass cryostat jacks. Courtesy of L. Gentini

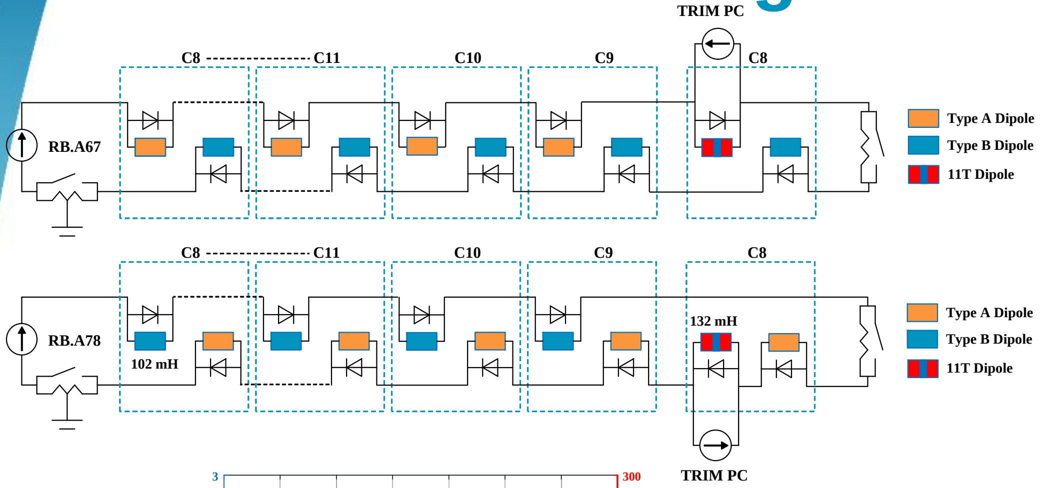
Geometry and alignment 3/3: other open points

- MAD-X positons and relative position taking into account the sagitta has to be communicated to WP15: direct communication between BE/ABP and EN/SMM?

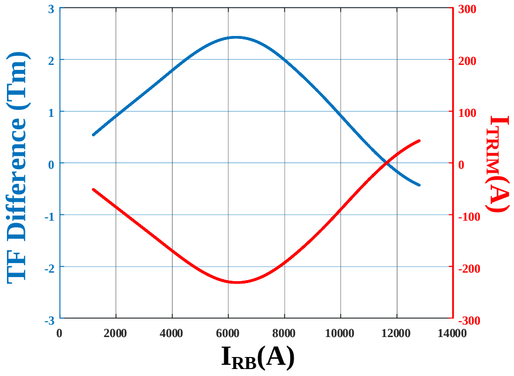
- By-pass cryostat et TCLD
  - Avant l'été les vérins rouges devraient être à nouveau testés dans une configuration « tunnel » (6 vérins dans un volume réduit) avec un poids de l'ordre de 600 kg et un outillage corrigé après des premiers tests pas très concluant. Sujet suivi par Delio Duarte Ramos et Patrick Bestmann – A suivre : modification was done!
  - En décembre, il y avait encore des discussions pour l'intégration des vérins

- Aimant LEP et 11T :
  - Demande pour une configuration des pieds E + S/T (+ volume d'accessibilité) en décembre 2017
  - Intégration sector valves / IFS boxes : OK
  - DN100 : Ajout d'un barreau pour mesurer le roll angle
  - Position et nombre de DN200 encore en étude : attention de conserver les lignes de visées SU libre (sans obstacle)

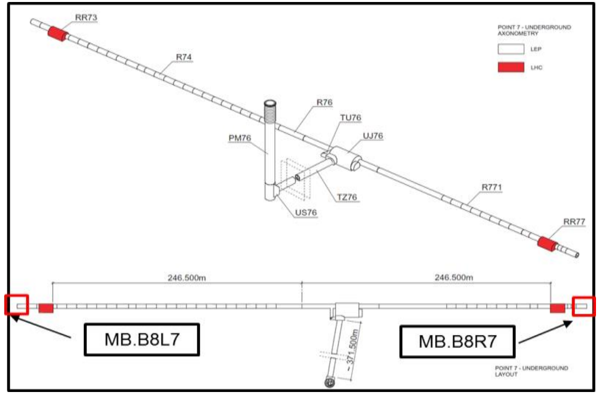
Powering of the 11T Circuit



- The 11 T dipoles are powered in series with the main dipoles
- The baseline foresees **one trim power converter** (for two magnets/four apertures) to compensate for bumps generated by difference of transfer functions between MB and 11T



TF difference and the required trim current vs RB main current

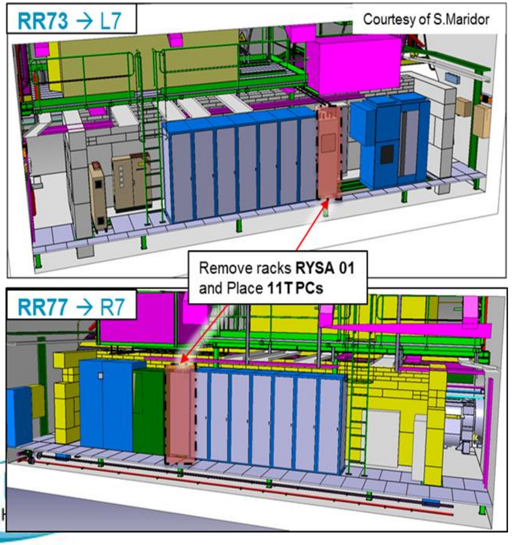


Trim Power Converters

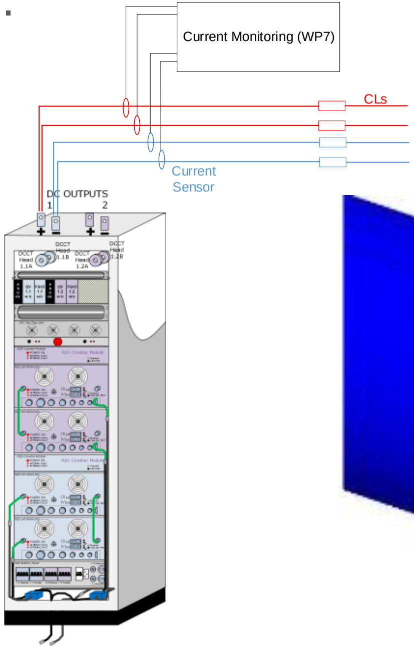
- **$2x70mm^2$ DC cables** (identical) per polarity. The resistance of the cables will naturally balance the current in both leads (WP17 ensure resistance variation <5%).

- **Current sensors on the DC cables** to be added to be able to monitor/protect from overcurrent (>130 A).

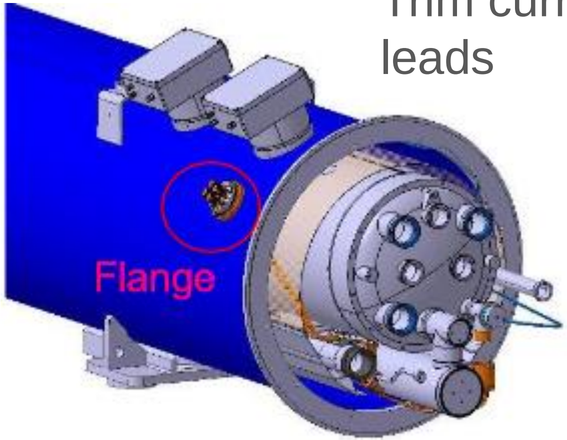
Dimensions:
- Height: 2.1 m
- Width: 60 cm
- Depth: 90 cm



Trim power converter



Trim current leads



11T dipole quench protection strategy

Failure of QH

- If one quench heater power supply fails, the heater power supply will be replaced during the next access.
- If two quench heater power supplies fail, the beam is dumped and the heater power supply is replaced.
- If one out of the sixteen heater circuits inside the magnet fails, during next long shut down the magnet will be replaced.
- If more than two circuits fail inside the magnet the individual case needs to be studied.

PIC requirements

- If there is a quench in the RB circuit (11T or other MB) → Beam dump, Fast Power Abort (FPA) in the concerned RB circuit and the 11T trim circuit
- If there is a powering failure in RB circuit → Beam dump, Slow Power Abort (SPA) of concerned RB circuit, no action on the 11T trim circuit. The 11T PC is auto-protected.
- Switch opening request by RB PC → Beam dump, FPA of concerned RB and trim circuit
- Powering failure in trim circuit → Beam dump, no action on concerned RB circuit. The power converter of the RB circuit is self-protected.
- Cryo-failure → SPA on concerned main RB and trim circuits

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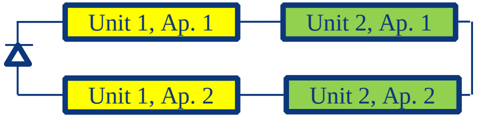
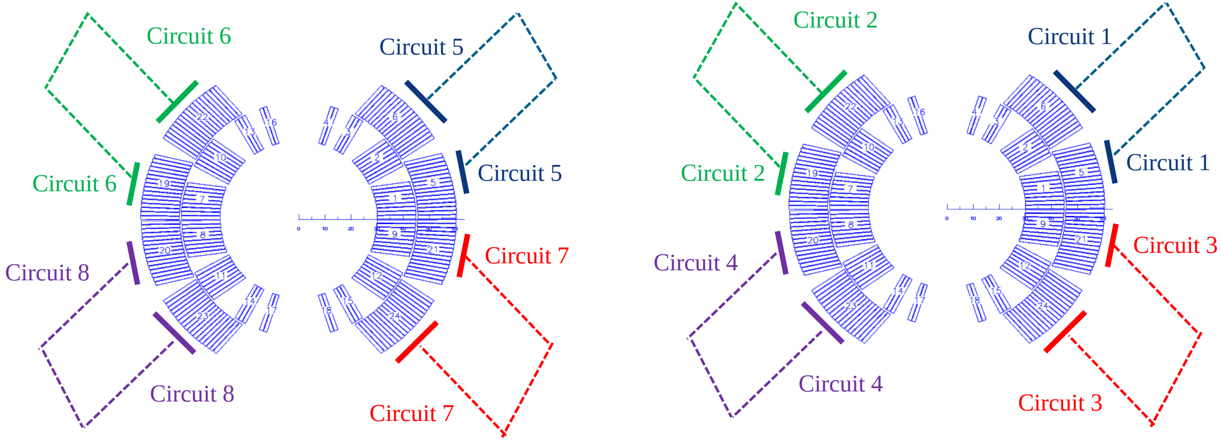
11T Quench Heater Circuits

- Each 11 T cryo-assembly is made out **of 2 x 5.3 m magnets connected in series** and protected by one standard LHC cold diode.



- The baseline protection scheme considers 2 heater circuits per coil (i.e. 4 circuits per aperture, 16 circuits per cryo-assembly).



Protection racks for the 11T

- 16 heater power supplies per 11T dipole cryo-assembly → 4 racks in total (8 heaters power supplies per rack).
- 5 racks will be manufactured (4 in the tunnel plus 1 as a spare) → 40 heater power supply units → 4 DQLIMs

Requirements for the design of the rack

- 11T dipole requires 16 DQHDS units
- The loss of more than 2 heater power supplies might compromise the 11T integrity
- The new QDS will be allocated in the RRs

Upgrades of:

- Mechanics of the current racks
- DQHDS units
- Interface module

11T dipole electrical test criteria

The maximum expected coil voltage at quench (V)	To ground	1450
	To quench heater	1400
Minimum design withstand coil voltage at nominal operating conditions (V)	To ground	3400
	To quench heater	3300
Minimum design withstand coil voltage at room temperature (V)	To ground	5000
	To quench heater	3300
Test voltage to ground for installed systems at nominal operating conditions (V)		2100
Test voltage to ground for installed systems at warm (V)		680
Maximum leakage current to ground (µA) – not including leakage of the test station		10
Test voltage duration (s)		30

Comments

- The minimum design withstand voltage at nominal operating conditions to quench heater is equal to the minimum design withstand voltage at room temperature to quench heater, as it was agreed with WP11 because the test cannot be pushed further
- The test voltage to ground for installed systems at nominal operating conditions does not follow the calculous procedure, but it follows the current test value of the RB chain.
- The maximum leakage current to ground and the test voltage duration might vary after testing the prototype before summer 2018

Meetings on 11T Circuit in Magnet Circuit Forum

Meeting	Topics	Speakers
Regular Meeting No. 3	11T vs QXF Quench Protection Performance	Susana Izquierdo Bermudez
Regular Meeting No. 9	Test Results of the Thermal Impact of the Trim Current on the Bypass Diode (11T Case)	Gerard Willering
Regular Meeting No. 10	Inner Triplet and the 11T Radiation Doses	Ruben Garcia Alia
Regular Meeting No. 11	Options for 11T Trim Powering Scheme	Samer Yammine
Regular Meeting No. 20	PIC for the 11T Trim Circuit; 11T Protection Instrumentation; 11T Trim Power Converter	Daniel Wollmann; Jens Steckert; Vicente Raul Herrero
Regular Meeting No. 22	11T Test Programme; 11T Trim Current Leads Status;	Frederic Savary; Lloyd Ralph Williams
Regular Meeting No. 23	11T Powering and Protection Document	Fernando Menendez Camara
Regular Meeting No. 29	Electrical Design Criteria for the HL-LHC Magnets and the Cold Powering Equipment	Fernando Menendez Camara
Regular Meeting No. 30	Protection Strategy and Hardware for the 11T Trim Current Leads	Reiner Denz
Regular Meeting No. 32	11T IFS	Ludovic Grand-Clement
Regular Meeting No. 33	11T Protection Rack	Fernando Menendez Camara
Topical Meeting No. 9	Follow-up of the Internal Circuit Review of 2017-03-17 with WP11	MCF; WP11
Topical Meeting No. 14	Meeting : Protection of the 11T Current Leads	MCF; WP7

Link to Regular Meetings

Link to Topical Meetings

16 presentations dedicated to powering and protection aspects of the 11T Dipoles in 13 meetings

Open points at MCF & document

Open points

- 11T dipole trim quench protection
  - Voltage taps
  - Bus-bar analysis
  - Find room for ½ rack in the RRs
- Last iteration on the 11T dipole PIC

Document – working version

- It describes the powering and protection of the 11T dipole circuit. The different elements of the circuit are described and simulations for currents and quench behaviour are shown. Measurements done on the 11T magnet are also reported. The magnet protection software and hardware specifications are discussed, as well as, case studies of normal and failure scenarios linked to the magnet circuit
- Last version of the doc: November 2017
- Once the last few open points are solved out (most likely before summer), the document will be directly updated.

EDMS no. 1764166

MP3-LHC magnet circuits, powering and performance panel

- Documentation will be handed over from MCF once installed
- Which circuits are to be modified and added?
  - Naming convention: RB_11?, R? (trim)
  - Databases (TIMBER, …)
  - Layout databases
- Hardware commissioning powering tests procedures

Interconnections

- Installation of interconnections in the tunnel: team and structure exists: DISMAC
- LHC tunnel will be carried out by the DISMAC Special Intervention Team (Sandrine, Nicolas)
- J.-P. Tock: The design, the procedures, components and validations are NOT part of DISMAC and my understanding is that the interconnections will be developed within the WP11 activities
- Procedures to be sent to the HL-LHC PSO (Thomas Otto) for verification

Integration, (de-)installation

- Documents were approved in October by ICL
- Update is foreseen October-November 2018
- Part of ECR (chapter on integration)

EDMS NO.	REV.	VALIDITY
1904996	1.0	Released

REFERENCE : INTEGRATION

HL-LHC INTEGRATION REPORT FOR INSTALLATION APPROVAL

WP11: POINT2 CONNECTION CRYOSTAT FULL ASSEMBLY INTEGRATION STUDY

Abstract

This document provides a general description of the Connection Cryostats (CC) integration in the LHC Machine for the HL-LHC new configuration. Installation of this equipment is planned for the Long Shutdown 2 (LS2). The document cover also some aspects of the integration of the TCLD collimator that will be mounted on the CC bypass. More information on the TCLD collimators integration study can be found in document EDMS 1903950.

It contains:

- Position of the new equipment installation and modification.
- Overview of the present and future configuration in the area under study.
- Description of necessary modifications in order to fulfil the requirements for the HL-LHC layout as in reference baseline EDMS 1833445 – High-Luminosity Large Hadron Collider (HL-LHC) – Technical Design Report V.0.1
- Impact on other equipment from integration point of view.

This document will serve as reference for the future Engineering Change Request (ECR).

This document, prepared and released by HL-LHC WP15 "Integration and (De-) Installation", is the results of contributions from several colleagues from HL-LHC Project and many other from various CERN Departments and Groups that have analysed and studied all the integrations aspects of: new equipment, modification of the existing one as well as modification of all the needing services (electrical, cooling&ventilation, transport, general safety, RP protection, etc.).

The status of this integration study is not frozen since some points need to complete the common analysis for definition of some integration/installation technical details.
Once EDMS approval launched, the documents will follow the standard HL-LHC QA procedure for documents revision.

TRACEABILITY

Prepared by: M. Gonzalez de la Aleja (WP15)	***Date***: 2018-02-15
Verified by: P. Fessia (WP15); M. Modena (WP15); Y. Muttoni (as ICL responsible) J.P.Corso (as ICL responsible)	***Date***: 2018-02-23
Approved by: P.Fessia (WP15 Leader); F. Savary (WP11 Leader)	***Date***: 2018-04-03
Distribution: HL-LHC PO, WPL, WPDL, WP15 Team; S. Bertolasi (WP 17.2); M. Battistin (WP 17.3); C. Bertone (WP 17.7); B. di Girolamo (WP17.9); K. Foraz (WP 17.10); T. Otto (HL-LH Safety Officer); C. Gaignant (HL-LHC Safety Officer); C. Adorisio (HSE-RP); M. Bernardini (EN-ACE); J. Gascon (HSE-OHS);	

Rev. No.	***Date***	***Description of Changes***
0.1	2018-02-15	Final draft for verification and discussion

EDMS NO.	REV.	VALIDITY
1904620	1.0	Released

REFERENCE : INTEGRATION

HL-LHC INTEGRATION REPORT FOR INSTALLATION APPROVAL

WP11: 11T DIPOLE FULL ASSEMBLY INTEGRATION STUDY

Abstract

This document provides a general description of the 11T Dipoles and TCLD integration in the LHC Machine for the HL-LHC new configuration. Installation of this equipment is planned for the Long Shutdown 2 (LS2).
It contains:

- Position of the new equipment installation and modification.
- Overview of the present and future configuration in the area under study.
- Description of necessary modifications in order to fulfil the requirements for the HL-LHC layout as in reference baseline EDMS 1833445 – High-Luminosity Large Hadron Collider (HL-LHC) – Technical Design Report V.0.1
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TRACEABILITY

Prepared by: M. Gonzalez de la Aleja (WP15)	***Date***: 2018-02-14
Verified by: P. Fessia (WP15); M. Modena (WP15); Y. Muttoni (as ICL responsible) J.P.Corso (as ICL responsible)	***Date***: 2018-02-23
Approved by: P.Fessia (WP15 Leader); F. Savary (WP11 Leader)	***Date***: 2018-04-03
Distribution: HL-LHC PO, WPL, WPDL, WP15 Team; S. Bertolasi (WP 17.2); M. Battistin (WP 17.3); C. Bertone (WP 17.7); B. di Girolamo (WP17.9); K. Foraz (WP 17.10); T. Otto (HL-LH Safety Officer); C. Gaignant (HL-LHC Safety Officer); C. Adorisio (HSE-RP); M. Bernardini (EN-ACE); J. Gascon (HSE-OHS);	

Rev. No.	***Date***	***Description of Changes***
0.1	2018-02-14	First draft for discussion
0.9	2018-03-09	Comments/observations from ICL responsible implemented.
1.0	2018-04-03	First Release (Version 1.0)

Integration, (de-)installation

Below are listed the remaining points as of 03/2018 (Point2 Connection Cryostat FULL ASSEMBLY INTEGRATION STUDY):

- If there is any new cabling, or equipment and power/signal cabling modifications to be performed at Connection cryostat area that have not been notified yet to EN/EL, the equipment owner must formally make the request via SNOW.
- Definition of final number and location of DN200 He release valves. This has a direct impact on: The identification of the exclusion areas on the floor
- DN100: Detailed solution on the plate that supports the survey sockets on Connection cryostats will be provided by WP11 (to place the cylinder required by Survey)
- Cabling of Sector valves, and piquages needed to compressed air not listed in this document.

Integration, (de-)installation

Below are listed the remaining points as of 03/2018 (11T DIPOLE FULL ASSEMBLY INTEGRATION STUDY):

- If there is any new cabling, or equipment and power/signal cabling modifications to be performed at 11T area that have not been notified yet to EN/EL, the equipment owner must formally make the request via SNOW.
- Final location of all necessary crates for quench detection electronics plus additional protection for trim leads at RR73 and RR77
    - Option1) Use interlocks and QPS racks or cryogenics racks
    - Option2) Install additional half-racks at RRs. Possible need of new a structure at RR77
- Definition of final number and location of DN200 He release valves. This has a direct impact on :
    - The identification of the exclusion areas on the floor.
    - Location for the LHC bridge needed at 8R7.
- DN100: Detailed solution on the plate that supports the survey sockets on 11T cryostats will be provided by WP11 (to place the cylinder required by Survey).
- Cabling of Sector valves, and piquages needed to compressed air not listed in this document.

HSE, TSO, HL-LHC PSO

- HSE-OHS (unit attached to the DG) has to validate all cold-mass production and quality procedure documentation. HSE-OHS has the role of a notified body
- The HL-LHC PSO (Thomas Otto) ensures that all regulations are respected and followed
- Conformity assessment with respect to the Pressure Equipment Directive (PED) by module H1 (production quality assurance)

Cold mass assembly

- Cold mass assembly, H. Prin
- Integration of current leads is on-going (Robin Betemps)
- Compliance to pressure directive, see next slides

Cryomagnet coordinator and MEB

- Approval required

Compliance to pressure equipment directive 1/2

EDMS NO.	REV.	VALIDITY
1891856	3.1	DRAFT

REFERENCE : LHC-LM-ER-0001

TECHNICAL NOTE

HL-LHC SUPERCONDUCTING MAGNETS

COMPLIANCE WITH PRESSURE EQUIPMENT DIRECTIVE (PED 2014/68/EU) ESSENTIAL SAFETY REQUIREMENTS

Abstract

Each of the HL-LHC magnet cold mass vessels will be designed, manufactured, commissioned at 1.9 K cryogenic temperature at CERN SM18 test facility from 2018 and installed in HL-LHC accelerator from 2019. These magnet cold masses have to comply with Safety Requirements which have been defined in the Launch Safety Agreement document EDMS #1550065. Based on these requirements, the present document makes a proposal to:

- Achieve compliance with the 2014/68/EU Pressure Equipment Directive (PED) Essential Safety Requirements (ESR);
- Describe the use of harmonized EN 13445 codes for design and manufacture of pressure equipment to comply with the PED;
- Describe the HL-LHC magnet cold masses technical documentation that describes how the applicable (ESRs) have been met;
- Identify an appropriate "intent" of assessment Modules H1 per PE directive in conjunction with the existing quality plan and required level of applied quality control.

Establish a roadmap for PED compliance in the case of the use of ASME Boiler & Pressure Vessel Code2 Section VIII versus the PED route plus major related codes when appropriate for the design, manufacture, inspection and acceptance testing of LMQXFA US AUP pressure vessels.

TRACEABILITY

Prepared by: A. Foussat (TE-MSC LMF)	***Date:*** 13.12.2017
Verified by: I. Bejar Alonso (HL QA), P. Ferracin (MSC-MDT), Th. Otto (HL PSO), V. Parma (MSC-CMI), H. Prin (TE-MSC LMF), R. Principe(TE-MSC LMF), Andrea Musso (TE-MSC MDT), T, Page (US-AUP PED officer)	***Date:*** 31.01.2018
Approved by: L. Bottura (TE-MSC GL), F. Savary (TE-MSC LMF WP11 leader), E. Todesco (TE-MSC MDT WP3 Leader), L.Rossi (HL-LHC Project leader)	***Date:***
Distribution: Jose Gascon (HSE-SEE), C. Arregui (HSE SEE), S. March (HSE SEE), *V. Parma (TE MSC-CMI)*, Delio Duarte Ramos (TE-MSC-CMI)	

Rev. No.	*Date*	***Description of Changes*** *(major changes only, minor changes in EDMS)*
1.0	13.12.2017	First version, Inputs received from HL LHC QA.
1.1	24.01.2018	Some typo corrections and clarifications implemented
1.2	01.02.2018	Version modified after Engineering Check, to be approved by WPL
2.0	09.02.2018	Figure 1 modified. Version released.

Table 5 extract on NDT Inspection from PED compliance report

Tests	EN Standards	ASME standards	Welding Qualification (if necessary)	Production		Acceptance
				Weld joint	Test plates /coupons (***)	
Non destructive tests						
Visual inspection	EN 17637-2017	ASME Section VIII-2, 7.5.2	100%	100%	100%	EN 5817
Inspection X-ray (film) and/or UT inspection	EN 17636-1 (RT) EN 12668-1/3 (UT) EN 13588 (PAUT) EN583-6 (TOFD UT)	ASME Section VIII-2, 7.5.5	100%	100%	100%	[1] EN 5817 class B (weld efficiency of 1)
Destructive Tests (**)						
Transverse tensile test, 1 required	EN 4136 EN 10002-1	ASME Section IX, QW-150	X			[2]
Longitudinal tensile test within the weld bead 1 required	EN 5178	ASME Section IX, QW-150	X			[3]
Charpy V-Notch test (4.2 K or 77 K)	ISO 17636-1	ASME Section VIII-2, 3.11.7 : Refers to SA-370 or ISO 148	X			[4]
3 required in heat affected zone	EN ISO 148-1					Energy > 40 J for group 8
3 required in welded metal	EN 377					
Bending test 1 required normal 1 required root	EN 910 ISO 7438	ASME Section IX, QW-160	X			[5]
Macrography *1 required*	EN 13639	ASME Section IX, QW-184	X		X (i)	[6] EN 5817
Micrograph *1 required*	EN 13639	ASTM E3	X			[7] EN 5817
Magnetic permeability *1 required*		ASTM A342	X			[8]
Specific qualification destructive test [9]						
Fracture toughness at RT, 77K*, 4.2K (both Heat affected zone, weld material)	ASTM E 399, ASTM E813-89	ASTM E1820	X			>= 130 MPa.m$^{1/2}$
Mnimum of 8 samples required (1 L, 1 T each at each temperature) (* optional)	(or eq. ASME Section VIII Div 3) ASTM E 1820					for weldments at 4K

Compliance to pressure equipment directive 2/2

Pressure vessel PED 2014 Directive implementation status

- Mandate to coordinate the compliance and enforcement of PED/2014/68/EU directive on HL-LHC cold mass started since 12/2017
- PE requirements translated into EN13445 and ASME sec VIII div 2 codes appliance.
- Topical meetings since 01/2018 with US-AUP to clear out ASME-ISO open discrepancy and make decision on most adequate inspection requirements. On going progress on case by case welds inspection plan
- HSE-OHS as approved third party on HL-LHC to review and approve all magnet cold masses main design and manufacture files for final PED compliance;
  - HSE-SEE should confirm internal organisation of cold mass documentation review/approval to HL-LHC PSO.
- EDMS 1891856/3.1 : ***COMPLIANCE WITH PRESSURE EQUIPMENT DIRECTIVE (PED 2014/68/EU) essential safety requirements – Approved***
- EDMS 1909767/3.1 : *Equivalence table ASME vs. EN codes on NDT requirements*

Status on 11T dipole :

- **EDMS 1711518/1.0 Structural analysis of LMBH 11T DS Dipole magnet cold mass done according to the new European harmonised standard EN 13445 in compliance with European Pressure Equipment Directive 2014/68/EU** (EDMS 1711518/1.0)
- On going UT qualification process on longitudinal cold mass welds, to be approved. No possible RT on end covers circumferential welds but past LHC inspection specification of 100% RT from qualification to 5% during production : Topic under discussion extended to WP3.
- 11T NDT Inspection plan and cold mass manufacture files to be approved by HSE-OHS.

HL-LHC Interface Specifications (IS)

- Template available: EDMS 1398340

1. Purpose
2. Applicable Documents
3. External Interface Requirements
    - 3.1 Identification
    - 3.2 Requirements (to be repeated *n*-times for each interface)
        - 3.2.1 Physical data
        - 3.2.2 Functional data
4. Internal interface requirements
    - 4.1 Identification
    - 4.2 Requirements
        - 4.2.1 Physical data
        - 4.2.2 Functional data
5. Annex
6. References

Engineering Change Request

Approval chain:
- TCC (HL-LHC)
- LMC (LHC) via Anne-Laure Perrot

- Beniamino Di Girolamo and Isabel Bejar Alonso: First draft due mid of May
- To be discussed today when content can be made available

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CH-1211 Geneva 23
Switzerland

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REFERENCE
XXX-EQCOD-EC-XXXX

To be processed by the relevant Configuration Manager
(see document ref. EDMS 1271880 for the detailed procedure) 17-05-03

ENGINEERING CHANGE REQUEST

WP11 Point7 11 T Dipole

BRIEF DESCRIPTION OF THE PROPOSED CHANGE(S):

The operation with proton and ion beam at both nominal and ultimate intensities requires a Large Hadron Collider (LHC) collimation upgrade with additional collimators needed in the warm insertions and in the dispersion suppression (DS) regions. A free longitudinal space of about 3.5 m is sufficient for additional collimators and can be provided by substituting one 14.3 m long 8.33 T LHC main dipole (MB) with a pair of 5.5 m-long 11 T dipoles. These twin-aperture dipoles will operate IN SERIES with the main dipoles and deliver the same integrated strength of 119 T.m at the nominal operation current of 11.85 kA. The operation field level of about 11 T calls for magnets based on the Nb3Sn superconductor.

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.
This document is uncontrolled when printed. Check the EDMS to verify that this is the correct version before use.

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To be processed by the relevant Configuration Manager
(see document ref. EDMS 1271880 for the detailed procedure) 17-05-03

ENGINEERING CHANGE REQUEST

WP11 Point 2 Connection Cryostat Full Assembly

BRIEF DESCRIPTION OF THE PROPOSED CHANGE(S):

A strategy to strongly reduce risk of quench is the installation of DS collimators, referred to as TCLD collimators, in places where higher levels of dispersion already exist. Around Point2, the ions debris losses hitting the DS dipoles are shifted in the connection cryostat zone by means of an orbit bump. The TCLD to intercept these losses will be then located in a newly designed connection cryostat in cell 11, thus avoiding installing 11 T dipoles in P2. On both sides of IR2, the existing connection cryostat cryo-assembly will be replaced with a string of three independently installed and aligned cryo-assemblies: two of these will be new connection cryostats (CC), with a bypass cryostat (QEN) installed between them. This new assembly will be called connection cryostat full assembly.

DOCUMENT PREPARED BY:	DOCUMENT TO BE CHECKED BY:	DOCUMENT TO BE APPROVED BY:
Daniel Schoerling et al.	**Hi-Lumi-LHC-WP11-Interfaces**	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.
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HiLumi HL-LHC PROJECT

Structure of ECR (similar structure for both)

Editor: D. Schoerling, content provider in brackets

1. Existing situation (D. Schoerling)
2. Description (with a focus on the deviation from the current status, once installation is done)
   - 2.1 Reason for the change (D. Schoerling)
   - 2.2 Integration (P. Fessia, final draft v0.9 released, v1.0 to be released Oct.-Nov. 2018)
   - 2.3 Beam dynamics (integrated field, field quality, field stability) (M. Giovannozzi)
   - 2.4 Vacuum modifications (M. Sitko)
   - 2.5 Cryogenics modifications (R. van Weelderen)
   - 2.6 Geometry and alignment modifications/changes (H. Mainaud)
   - 2.7 Powering of the mains and trim circuit (H. Thiesen, S. Yammine, draft description 2.1-2.7; EDMS 1664166)
   - 2.8 11 T dipole circuit power and protection modifications (D. Wollmann, F. Rodríguez: draft available)
     - 2.8.1 Introduction to changes in the quench protection hardware
     - 2.8.2 Changes to the quench detection system
       - a. Hardware
       - b. Cabling
       - c. Location
       - d. Interlocks
       - e. Controls
     - 2.8.3 Changes to the n-QPS
       - a. Hardware and location
       - b. Cabling
       - c. Configuration
       - d. Controls

->Continuation next slide

Structure of ECR

2.8.4 Changes to the rack containing the Heater Discharge Units

a. Hardware and implications

b. Location

2.8.5 Changes to Powering Interlock System (PIC)

2.8.6 Protection of trim current leads

2.8.7 Cabling

3. Impact

3.1 Impact on items/systems

3.1.1 LHC Layout (WP15/EN-ACE)

3.1.2 WP 11 drawings (D. Schoerling)

3.1.3 Powering of the mains and trim circuits (H. Thiesen, S. Yammine, draft available)

3.2 Impact on utilities and services (short concise tabular description of impact)

3.2.1 Electrical distribution (J.C. Guillaume)

3.2.2 Electrical cable pulling (any one concerned, please provide input to D. Schoerling)

3.2.3 DEC/DIC (please forward any request to D. Schoerling)

3.2.4 Racks (please forward any need to D. Schoerling)

3.2.5 Vacuum (short list of impact, to not repeat the description 3.3)

3.2.6 Special transport/handling (C. Bertone)

3.2.7 Temporary storage (?)

3.2.8 Alignment and positon (H. Mainaud)

3.2.9 GSM/WIFI networks: Should be available during installation?

3.2.10 Cryogenics (R. van Weelderen) ->Continuation next slide

Structure of ECR

4. Impact on cost, schedule and performance
    - 4.1 Impact on cost (F. Savary)
        - 4.1.1 Detailed breakdown of the change cost
        - 4.1.2 Budget code
    - 4.2 Impact on schedule (F. Savary)
        - 4.2.1 Proposed manufacturing schedule
        - 4.2.2 Proposed test schedule
        - 4.2.3 Proposed installation schedule
        - 4.2.4 Contingency and risk
    - 4.3 Impact on performance
        - 4.3.1 Dynamic aperture, impedance, e-cloud, etc. (M. Giovannozzi)
        - 4.3.2 Optics/MADAX (M. Giovannozzi)
        - 4.3.3 Machine protection (D. Wollmann)
        - 4.3.4 Cryogenics (R. van Weelderen)
        - 4.3.5 MP3 (A. Verweij)
        - 4.3.6 Operation (M. Pojer)
5. Impact on operational safety (T. Otto)
6. Worksite safety (T. Otto)
    - 6.1 Organization
    - 6.2 Regulatory tests
    - 6.3 Particular risks
7. Follow-up of actions by the technical coordinator (?)