FIRST LOOK AT THE RE-COMMISSIONING PLANS AFTER LS1: HWC- DRY RUNS - SYSTEMS COMMISSIONING

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Abstract

In 2015 the LHC will enter a new era. The energy of the machine will be increased by more than 50%; the beam stored energy will increase maybe by a factor 2 or even more. A thorough re-commissioning of all systems will be fundamental for a safe operation with beam. The experience gained in the last three years will be as well critical in defining the needed commissioning steps.

PREAMBLE

In the preparation for this work, some of the relevant systems experts have been contacted, to enquire on the major modifications that will be done during the Long Shut-down 1 (LS1): all hardware which will be replaced or repaired and all software implementations could demand for new qualifications and additional time need. The "delivery" date for all equipment and the guessed time needed for the re-commissioning were demanded. Special stress was put on the interdependency between the different systems, and the necessity for dry runs was also investigated as an important commissioning step. Finally everybody was asked whether the 2015 re-commissioning would more look like the one of 2008 or 2010.

Some implications of the tight scheduling are already clear if we take a look at the general LS1 planning:

- the R2E activities are finishing late, and they will delay the powering of the superconducting circuits at point 5 and 7;
- sector 45 and 56 are among the last sectors to be tested, which means that the LBDS energy tracking tests will be performed in ideal conditions only at the very end of the powering test period;
- the powering tests and the dry runs of the machine checkout will have to be done mostly in parallel.

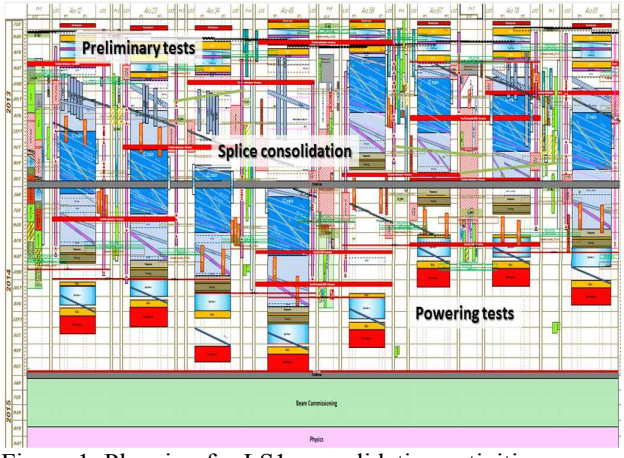

Figure 1. Planning for LS1 consolidation activities.

THE SUPERCONDUCTING CIRCUITS

The Copper Stabilizer Continuity Measurement

Among the powering tests to be performed on the superconducting circuits, the CSCM (aka, thermal amplifier) will be the first one to be executed.

The CSCM is a technique initially proposed by H. Pfeffer and later developed by H. Thiesen, which could be used to investigate the thermal runaway of faulty splices of an entire 13 kA line, including the current leads to pigtails, the splices between magnets and the diode connections.

The procedure consists in powering a main (dipole or quadrupole) circuit while it is kept at 20 K: the diodes are all closed by a voltage pulse, so that the magnets are taken out from the loop; a 12 kA current is then circulated inside the busbar/diode circuit, to check whether faulty splices are detected, which would lead to a thermal runaway.

The CSCM will be executed as a type test on a sector at the beginning of LS1, before the consolidation. If qualified, the method will be possibly applied to the rest of the machine at the end of LS1.

Superconducting circuits commissioning

Many interventions will be performed on the superconducting circuits during LS1, either maintenance activities or system upgrade. Just to give some examples:

- the QPS will be upgraded on many aspects, like additional systems for the diagnostics of the quench heater circuits (measure of the resistance of the heater circuit with high precision, in order to see precursors of eventual faults), specific transducers for precision measurement of the power pulse during heater discharge and in general detectors change and firmware upgrade;
- the power converters will undergo major modifications, including active filters and auxiliary power supplies replacement;
- following R2E relocations, many electronic equipment will be removed from areas close to the tunnel and put far away
- cables will be re-routed (mainly at point 5, due to R2E) and the sheaths of many of them replaced.

Following the numerous modifications and upgrades of the superconducting circuits, a massive campaign of individual system tests will be performed by the equipment owners; in particular, for the superconducting circuits, the tests will have to check for the protection functionalities and for the efficient interface between all powering and protection systems, apart for their

reliability. Also, all cable activities will require for short circuit tests and heat runs.

As for all machine protection elements, the most critical part will be the interface between the different systems, because of the delayed delivery of one with respect to the other and their non-synchronized commissioning.

For the commissioning of the superconducting circuits, new powering procedures will be needed, to keep into account all hardware and software modifications. What will follow is a brand new commissioning, where sector 67 will be the pilot and longer one, hopefully with a fast learning curve on the others.

Time needed and strategy

In terms of time required to commissioning the superconducting circuits and the strategy to be adopted, not much should change with respect to what done in the past campaigns. The main difference will be of course in the commissioning current, which should aim at being the one corresponding to 7 TeV, but some limitations might apply: some 600 A circuits could be limited according to their known weakness and operation need; some other parameters could be relaxed, to improve flexibility and increase the performance. No surprises should be expected after the splice consolidation and the powering tests to be performed at the beginning of LS1.

Automation should play a fundamental role, not only in speeding up the test execution, but also in ensuring a safer commissioning, of which QPS would certainly profit. Also the traceability of tests execution and results would be improved.

More than 6 months in total will be needed, along which the manpower (above all at the beginning) could be an issue, being the operation team deeply involved in the splice consolidation. About 3-4 weeks per sectors have been allocated to the commissioning, but the real length will mostly depend on the time needed to train the main circuits. We know, in fact, from 2008 that the training could be long and we will be obliged to start from an initial energy of about 6.5 TeV (with a slightly higher commissioning energy, to allow a comfortable operation), if we don't want to experience too many quenches. If we suppose to perform 2-3 quenches per day on each sector, in about 1 week the main circuits could be ready to operate at 6.5 TeV.

SYSTEM RE-COMMISSIONING

LBDS

Three main consolidation activities are foreseen on the LHC Beam Dumping System:

- the consolidation of all HV generators for 7 TeV operation;
- the installation of the missing diluters (2 per side), needed for the intensity increase;
- the solution of the 12V problem, with the installation of new synchronization unit from the Beam Interlock to the kickers.

For the commissioning of the LBDS, the experts have foreseen the test of the generators directly underground and not in the lab. This will lead to possible interference with the powering tests in the nearby sectors.

A reliability run will be needed, to validate the system for operation at 7 TeV: this will be done in local during the 1st semester of 2014. Starting from late summer '14, the dry run phase will start, which includes the sequencer use, with arming sequences, ramp and dump; this will lead to the verification of possible faults. The BIS loop will be in local for this testing phase.

The dry run part will require solid software already available from early summer; no change is foreseen on the LBDS software, but there will be changes at the level of the FESA classes which could be an issue.

Finally, time will be needed before beam to test the whole system in the final configuration.

Others from ABT

A new 3m-long TCDQ will be installed, for which an extensive control validation will be carried out. The delivery of the whole system is foreseen for the end of the 1st semester of 2014, which means that there might be some conflict with the powering tests and time issue for its qualification.

Concerning the kickers, all magnets will be replaced. A long conditioning will be needed, after which the dry run could be performed, starting from end of summer '14.

Also, for the MKQA, a modification of the internal electrical distribution will be done, which will not affect the commissioning. A request was as well made to change the length and amplitude of the modulation.

RF

The first big intervention done on the RF system will be the modification of the klystron cooling (8 klystron over 16 will have to be changed). This implies the re-test from the end of summer '14, with short circuits on the wave guides to allow powering without closing the area. In fact interventions in the tunnel will be still ongoing and also some conflict might appear with the powering tests. The full testing will be nevertheless difficult, due to the absence of BIS connection till very late; electrical power and demineralized water will be needed.

The second important intervention will be the replacement of one module, containing the sick cavity 3B2. A long conditioning (between 1.5 and 2 weeks) will be needed and the RF zone will have to be closed, which implies a possible interference with the powering tests and other activities in the area.

Software-wise, the major modification will be the migration to the new versions (e.g., FESA3). All RF VMI front-ends will be moved to Linux, for which part of the drivers will be re-written.

ADT

A complete new system is being planned by the owners, which will require a lot of work for cabling, front-end, twice the number of pick-ups, a new signal

processing unit and a new algorithm. Unfortunately not much can be done without beam and the re-commissioning will not take less time than in the past, even if experts are planning for some automatic systems to speed up the tests.

Collimators

Between 22 and 26 new collimators will be installed in LS1, mostly BPM collimators as TCTs at all interaction points and 2 TCSs at point 6, plus 1 or 2 new TCLs per side/beam at IP1 and 5. All these new collimators will require for calibration and a full re-commissioning for machine protection.

In addition, a plan is foreseen to move periodically all collimators to avoid some get stuck, and to put protections in place around the collimators to avoid damages during the LS1 activities.

From the software point of view, no radical change will be done, but the new BPM collimators will require new control software, which has nevertheless already been tested in SPS in a prototypal form.

In the baseline, no systematic replacement of LVDT or step motor is foreseen, since no problem of ageing has been observed nor problem of radiation. Some acoustic check will however be performed.

Beam instrumentation

Many interventions will be carried out in LS1: the BPM and BLM cooling, the modifications on the HW of the orbit feedback, the attenuators on the interlocked BPMs, additional HW on the tune system, new optics of the light monitors and thinner wires for the wire scanners. Most of them will only be tested with beam. What will be tested beforehand is the cooling system on the racks of the BPM and BLM, which will require a reliability run, to be performed well in advance with respect to the beam. The BLMs will be also tested with a radioactive source before beam.

Vacuum

New "transparent" ultra-fast valves are under study by the vacuum group and could be installed close to the RF cavities to avoid pollution in case of an incident like the one occurred in sector 34. They would close in about 20 ms and need to be interlocked not with the vacuum system, but (most presumably) with some powering signal.

From the software point of view, a new tool should be available which would ease the check of all interlocks at the beginning of machine checkout.

Beam Interlock System

Several issues affect the BIS in view of LS1:

- the electronic interfaces which pilot the CIBUs will be touched or moved in many places;
- the optical fibers are subject to ageing and they are fragile and could be damaged easily, plus new fibers will be pulled after moving the equipment from UJ56 to USC55;
- all BIC processors in the Front-End will be changed due to the change in software and technology no more supported.

All this would demand for a conservative re-qualification of all user inputs, that is all CIBUs for all users. Such a re-qualification should be done in the real conditions, which is with all users TRUE, and would require 6 months for the 250 connections: this is unfeasible. That's why a more pragmatic approach has been chosen: all users moving their electronic interface will have to declare their intervention (awareness raising campaign). For these changes, re-commissioning will be done and about 3months before restart, BIS experts will need to enter in test mode on all CIBUs for loop A and B; in addition, 1 week will be needed for attenuation measurements (budget is between 3 and 6 dB and the BIS experts will have to pass after intervention completion, to clean the connections).

Powering Interlock Controller

The most important changes are those related to R2E, namely the displacement of 9 PIC units (for UJ14/16/56) and new cables pulled, which will have to be qualified. A complete re-commissioning of those systems is needed, which will happen just before the powering tests.

More generally, all units will have to be individually tested, plus the PIC1 and PIC2 tests will have to be performed on the superconducting circuits.

A change will be applied in PVSS for the global protection mechanism (which prevents from powering any circuit in a powering subsector when the big circuits are in fault): it could be switched ON and OFF, allowing for more flexibility during the powering tests.

Also, a new solution will be deployed for the PIC-LASS interface. This is presently based on software (Laurette's interlock); a new PLC will be connected with the access system and a new FESA class will be created in SIS for the access conditions.

Finally, a singularity has to be reminded on the temperature interlock of the top part of the current leads: everywhere connected to the power converter, it will be connected to the PIC in RR53 (cabling issue) and will have to be tested.

Fast Magnet Current Monitor

The FMCM will not be changed in the LHC, but the displacement in UJ56, following the R2E works, will demand for the re-commissioning of the system in that location.

Cryogenics

All machines for cryogenics will be dismantled and then remounted during LS1; all valves and attenuators as well. The control software will be rewritten.

After all interventions, 2 months will be needed for the re-commissioning of the production, 4-5 weeks for the cool-down of all magnets and 1 week for the cryo-tuning. In addition, the cryogenics experts request for some time to tune their system for frequent ramps.

Manpower could be an issue, since only one third of people are left from the first commissioning in 2008.

Controls

All the interventions performed at control level (hardware and software) will require for dry runs as a fundamental re-validation.

MACHINE CHECKOUT

The objectives of the machine checkout, as defined in 2008, are:

- drive all relevant systems in a synchronized way through the standard operational sequence
- check functionality of the control system from the control room high level applications
- check the beam instrumentation acquisition chain
- check low synchronization
- check all equipment control functionality
- check machine protection and interlock systems.

The differences from 2008 are various, since the infrastructure is already present and the software tools are available and well developed. On the other side, a lot of changes will be done in LS1 and the planning of restart is compressed, with a late delivery of many systems.

Preliminary, regular meetings should be organized with the equipment owners by the machine checkout responsible, starting from spring ’14; individual system tests (equipment tests toward operational condition) should be performed by the equipment responsible and reported at these meetings.

On a later phase, functional tests will be performed depending on the advancement of the hardware commissioning and dry runs should be coordinated by OP with the equipment responsible starting from late summer ’14.

Powering tests and machine checkout will cohabit for the last period. BIS checks should be done one week before the end of powering tests and the real machine checkout test can only take place at the final phase when the powering tests will be completed and should last about 2-3 weeks.

CONCLUSIONS

It is a common believe that the one of 2014 will be a brand new commissioning. A lot of experience has been gained in the past years, but there will be two years without running the machine and a lot of changes will be done to hardware and software; in addition, there will be new people to train and the members of the operation team will be busy till the end on the consolidation activities.

The software will have to be ready from mid-2014.

Equipment tests and dry runs will be important to revalidate all systems, but they will be possible only from end of summer ’14 and will have to be well coordinated.

At least 3 weeks of real machine checkout will be needed once the powering tests are over.

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