SUMMARY OF SESSION 1: LS1, HW COMMISSIONING, POWERING TESTS - COMING OUT OF LS1

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INTRODUCTION

The main objective of the first session (as it was oriented) was not to list what has been done in LS1, but to clarify what is left to do in the LHC before beam, in two senses: what is left to do for the completion of LS1 and the preparation of the machine for beam, and what will not be completed during LS1. In particular, the speakers where asked to focus on items which could have an impact on the first run at 13 TeV and the main questions they were asked to answer are:

- From the issues before LS1, what was addressed and what could not be modified?
- What is the predicted impact of hardware changes?
- Can we expect surprises after LS1?
- What can be done to mitigate issues in case they come up?

The first part of the session focused on the powering tests, with two presentation on the status of the superconducting circuits:

- Non-conformities (solved and pending) on the Superconducting Circuits, A. Verweij
- Re-commissioning of the Superconducting Circuits, M. Solfaroli

In the second part, the attention was moved to the "rest" of the machine, with two talks on the remaining NCs all around the ring and the expected performance in terms of impedance and RF heating:

- Other Non-solved NC's across the LHC Ring and Potential Impact on Performance, V. Baglin
- Expected impact of hardware changes on impedance and beam induced heating during run 2, B. Salvant

Finally, the status was presented of the most critical systems in the machine, RF/ADT and injection/extraction elements:

- ADT and RF after LS1, A. Butterworth
- LBDS and Kickers after LS1, W. Bartman

As an additional element, CMAC noticed that "there appear to be two main categories of NCs; those that are critical to performance of the machine and those that are not. It would be helpful to clearly identify these two categories of Non-Conformities".

Some elements in this direction are already highlighted in this summary.

NON-CONFORMITIES (SOLVED AND PENDING) ON THE SUPERCONDUCTING CIRCUITS

Arjan gave an update on the status of readiness of all superconducting circuits for Run II. In fact, during LS1, all non-conformities that were limiting the performance of the machine were addressed and all those preventing to operate at high energy were fixed. Nevertheless, some non-critical non-conformities are still present.

Concerning the main circuits, 15 main dipoles and 2 main quadrupoles were replaced within the SMACC (Superconducting Magnets And Circuits Consolidation) project, due to electrical and magnetic NCs. The quality of the splices after SMACC is extremely good and they are all below the 5 μΩ excess resistance.

No issue is finally expected from the main circuits for operation at high energy, even if a number of quenches is expected during the commissioning campaign, which is estimated between 90 and 130 for the main dipoles.

Concerning the other circuits, some non-conformities or local limitations apply:

- For RD3.L4, the max current was reduced from 5850 to 5600 A, sufficient for 6.74 TeV;
- Four 120 A circuits in the inner triplets in L1 and L2 were not repaired during LS1 and are then still condemned;
- Some magnets on the 600 A circuits have been bypassed due to electrical problems, but in agreement with ABP colleagues and with an estimate negligible impact on the performance.

Finally, no limitation from the superconducting circuits is expected for the operation at high energy.

Q&A

Q. King asked why current is reduced in some low current circuits. A. Verweij answered that these circuits present probably an internal short that cannot be fixed during LS1.

P. Collier asked if the limits on the inner triplet correctors could be a potential limit for performance (β^*reach). M. Giovanozzi answered that these correctors are not needed till 60 cm β^* as observed during the machine developments in Run 1. For lower β^*, MD time is required to explore the impact on performance.

M. Pojer asked if it is planned to change the detection threshold for the undulator which was a weak point in Run 1. A. Verweij answered that tests are on-going in SM18 to see if we could increase the ramp rate. This will be presented at the next LMC.

RE-COMMISSIONING OF THE SUPERCONDUCTING CIRCUITS

The re-commissioning of the superconducting circuits after LS1 requires the execution of more than 10000 powering tests on the almost 1600 circuits. And this will have to be done in about 5 months: this constitutes a challenge similar to the one of 2009. The main differences with respect to that period is that not all the circuits were heavily modified as done during LS1 and (more important) the energy was at that time limited to 3.5 TeV. Now the objective is to run at 6.5 TeV, with an expectation, as said, of more than 100 quenches for the main dipoles only.

Matteo illustrated all efforts that were put in place to have good hardware and software for this campaign, with a special attention to the automation of test.

Prior to the powering tests, the short-circuit tests and the CSCM were performed. The first ones revealed some non-conformities that could have been critical for the machine and would have slowed down the powering tests. The Copper Stabilizer Continuity Measurements are done to validate the full busbars-splices-diodes path, and the results so far obtained show the good quality of the consolidation job done during LS1.

Q&A

N. Holtkamp asked for precision about the so-called "new" QPS board. M. Solfaroli precised that the New QPS is indeed the one already installed before LS1 and used during RUN 1. What is presented in the talk is a new detection system for the CSCM test.

The time to recover from a quench was questioned, to evaluate how long will be the training campaign. The estimation with 2 quenches per sector per day is about 1 week of training to reach 6.5 TeV.

OTHER NON-SOLVED NC'S ACROSS THE LHC RING AND POTENTIAL IMPACT ON PERFORMANCE

Vincent gave an overview of other non-conformities (mainly related to vacuum) that have not been fixed in LS1 and tried to draw for them the possible impact on operation or on the activity during the coming technical stops.

Among the non-conformities that could have an impact on operation, the most important are those related to the collimator 5^{th} axis for the TCTPs in IP1 and IP5 (which implies that we cannot afford the risk of damaging them and will require an intervention during 2015 YETS to fix them) and the presence of ferrite in several components, that, if heated, could outgas and produce a pressure rise. Concerning the TDI, it has been sectorised during LS1, to allow exchange or reconditioning if needed, and the pumping systems has been upgraded with NEG cartridge; nevertheless, it will still suffer from resistive wall effects and beam induced heating and outgassing.

The impact on the technical stops will mainly come from the discovery, during LS1, of the multiply bellows leaks: to avoid producing new ones, thermal transients should be limited as much as possible. In addition, some leaks were not fixed in LS1 and will be fixed in LS2.

Also the bake-ability of some components will be an issue for future interventions, and this will have the consequence of a reduction of the NEG coating life time and the lengthening of the intervention time.

Q&A

M. Pojer wanted to know where vacuum activities stand in the general planning. V. Baglin answered that all sectors are closed, LHCb is under closure and within one month all LSS should also be closed, which corresponds to the planning.

P. Collier asked if the solenoids around MKI will be put back in place for RUN 2. V. Baglin specified that upstream of vacuum valves, in warm regions, the solenoid have been replaced by NEG system. The solenoids will be put back only in the warm-cold transition region around IPs. A second question concerned the dilution kicker (MKB) status. V. Baglin answered that the system is now completed, the new module has been installed and with the same pumping speed as before LS1, so with the same possible limitation on vacuum performance.

S. Redaelli mentioned that the ferrite in the collimator is by design and cannot be called a non-conformity. M. Jimenez specified that in the functional specification of the LHC it was explicitly mentioned that no equipment should go above 120 degree when installed so that all equipment containing ferrite should be thermalized before installation.

EXPECTED IMPACT OF HARDWARE CHANGES ON IMPEDANCE AND BEAM INDUCED HEATING DURING RUN 2

An impressive effort has been done during LS1 by all equipment groups to assess and reduce the impedance of their devices. Benoit listed many of the interventions done and stressed on the fact that new equipment should by default remain in the shadow of the current LHC impedance.

Concerning the beam induced heating issue, Benoit listed the predicted impact of consolidations on the RF heating and the result of the simulations with changing bunch length: an increase of the bunch length from 1 to 1.25 ns, would drive a reduction of the heating from 30 to 95%, depending on the systems.

Concerning the most critical systems in terms of beam induced heating during Run I, Benoit showed the modifications done on the TDI, the BSRT and the MKIs. For the TDI, a stiffening of the beam screen was applied, together with the refurbishment of jaw mechanics; the copper coating was removed from the beam screen and temperature probes were added on the lower jaw. In the BSRT, the mirror and mirror holder geometry were

modified to attenuate the RF mode; no ferrite was installed and RF studies were done, to validate the design. Lastly, in the MKIs 24 screen conductors are installed and systematic measurements are done before installation.

Q&A

P. Collier asked if we may expect problems at the recombination chamber with the increased bunch intensity. B. Salvant answered that the estimation with HL-LHC numbers are OK.

Following a question on the source of the heating, B. Salvant answered that with the intensity and bunch length expected for RUN 2, the heating is mainly due to single bunch effect.

ADT AND RF AFTER LS1

The main change during LS1 on the RF side was the replacement of a faulty cavity module (limited to 1.2 MV). Andy showed also all upgrades done to improve the reliability of the system, and he talked about the new diagnostic installed for the bunch-by-bunch phase measurement. Concerning the controls, CPUs were replaced and moved to linux, but the upgrade to FESA3 will be done only during Run II. For the operation in RunII, the capture will be done with 6 MV, as in Run I. A long and detailed planning of re-commissioning is already underway, but the real commissioning will only start after cool-down.

A lot of hardware and software modifications were done on the ADT too. New important feature are four pick-ups per beam/plane, an improved S/N ratio and other implementations. In particular, an “observation box” is being developed, which make ADT and RF bunch-by-bunch data available to external applications and which should be connected to the LHC instability trigger network.

A possible issue to be checked for the ADT is its compatibility with the new UPS: the ADT base-band signals (3 kHz-20 MHz) are transmitted over coaxial lines from SR4 and they were perturbed by ground currents from old UPS, with switching frequency 5-8-16kHz. The newly installed UPS's produce very different noise spectra and their compatibility with the ADT system will have to be studied in detail.

Q&A

W. Hofle questioned about the commitment of the RF group to provide the cavity phase noise measurement tool. A. Butterworth answered that it is planned for mid-2015.

O. Bruning asked if the issue with the “America” cavity has been investigated. E. Jensen answered that there was a request from LMC to not start dismantling “America” for investigation till the commissioning of “Europa” is completed to keep it as spare in case of need.

M. Pojer asked when the tests with the new UPS system are planned. A. Butterworth answered that they are now planned for end of October 2014.

LBDS AND KICKERS AFTER LS1

Wolfgang started showing the new 24 screen-conductor design for all MKIs: with respect to the old 15 conductor design, this will bring a net reduction of the deposited power, which will go down to 50 W/m. In addition, the improved cleaning procedure of the ceramic tube will reduce the UFOs. For what concerns the hardware modifications on the extraction system, the main ones are the new TSDS powering scheme and the new TCDQ. The new scheme is meant to cope with missing dump request in case of powering issues: 3 independent VME crates (1 crate for each TSU) are separately powered; in case of internal failure, a synchronous dump is issued from the redundant crate. This means an improved safety, but a higher complexity in the system and, of course, a reduced availability.

For the new TCDQ, the graphite absorbers have been replaced by a sandwich of graphite and Carbon fibre reinforced Carbon (CFC).

Important software modification are also foreseen for the injection and extraction systems. Mentioning two, the TDI gap interlock, with redundant interferometric measurement, and the interlock for the MSI current, which will be ramped down, while beam energy ramps up.

Q&A

R. Jacobson asked what are the expected losses at injection for the 25 ns bunch spacing beam and with the BCMS type beam for LHCb. W. Bartman answered that the 25 ns beam should be cleaner from injection losses point of view than the 50 ns beam.