LHC YETS RECOVERY

M. Pojer, CERN, Geneva, Switzerland

Abstract

16 days are allocated in March 2016 to prepare the machine for the beam. Around 7000 powering tests will have to be performed to re-commission the superconducting circuits. An extensive list of tests will have to be executed as well on the various systems affected by interventions during YETS. A preliminary planning for these tests will be shown.

THE SCHEDULE

The driving activities

The main activities determining the length of the year end technical stop (YETS) are the following:

- Cooling and ventilation
  - 3 weeks of stop for the mechanical cleaning of the cooling towers, mechanical and electrical maintenance and bugs fixing
- Cryogenics
  - The maintenance is needed on all cryo-plants, with heavier maintenance and consolidation in IP4 (A) and IP6 (A), heavy corrective maintenance (repairs) also needed in IP8 (B)
  - The baseline is to keep the Helium in the arcs except sectors 7-8 and 8-1, which means that the magnets will be filled with LHe in cold standby at 3.5 K – 4 K, the LSSs will be in GHe at 20 K and the DFBs will be empty with the current leads in cold standby; the sectors 7-8 and 8-1 will be emptied, and in cold stand by with GHe
  - The RF cryo start will be given on February 22 to allow the RF conditioning (4wks requested)
  - The last cryostarts will be back on March 4 (earlier in sectors 1-2, 3-4, 4-5, 7-8)
- UPS tests on the whole machine
  - Recently approved by LMC, the tests can be done only after the cryo start and constitute a hard limit for the readiness of all systems.

The key dates

The key dates for the YETS are the following:

- DSO tests (machine in general mode before), with patrol scheduled on week 8 and the DSO tests on February 26 (and 27)
- March 1, beginning of UPS tests
- March 4, LHC tunnel closed and beginning of powering tests
- March 16, end of powering tests, experiments closed and (official) beginning of machine check-out
- March 21, beginning of beam commissioning.

CRITICAL ACTIVITIES WITH POSSIBLE IMPACT ON THE PLANNING

Three activities are presently on the critical path and could impact the end date of the YETS. The first one is the activity of consolidation of some collimators, to re-establish the 5th axis. 12 Collimators will be removed and re-installed in LSS1 and in LSS5; the vacuum layout has to be modified, to recover the TCTP collimators' 5th axis translation. Due to RP issue, the activity can only start on 4th of January.

The TDI replacement is another critical activity, since minor contingencies are included in the baseline: both TDIs will be removed during W51 and reinstalled during w1 and w2.

Concerning the change of ferrite of the Beam Wire Scanner in LSS4, due to the late delivery of ferrite, the final decision about the installation will be taken only by the end of January.

ACTIVITIES THAT COULD IMPACT THE POWERING TESTS

Among all activities performed during the YETS, those critical for the powering tests can be identified. The readiness of the cryogenics and all services is mandatory for the execution of the tests, that's why all interventions will have to be completed for those systems.

EPC

Many interventions are planned during YETS; the main is the FGC CPLD and software upgrade. For the FGC CPLD upgrade, a local access all over the machine is needed for the reprogramming; the version was already tested in S78, so no risk of failure. The PIC2 tests will have to be done, to revalidate the systems. The FGC software upgrade is needed to correct the bugs seen during Run 2 and will require additional tests during powering.

Another important intervention is the current calibration of the high current circuits (the main dipoles, the main quadrupoles, the inner triplets and the RMSIs), which does not require special tests of validation.

Additional intervention of maintenance and power module replacement will be carried out, but no major impact is expected on the re-commissioning.

MPE-QPS

Many activities are planned for the QPS in the coming weeks. The most important and critical is the installation and commissioning of radiation tolerant detection systems for the 600 A circuits in RR13, 17, 53, 57, 73 and 77: this could strongly impact the commissioning time in case something goes wrong, that's why it will be important to get a sector to test these new systems as soon as possible.

Another critical activity is the upgrade of the firmware for the nQPS DAQ systems allowing easier recovery from local bus errors (436 units concerned in all 8 sectors), whose impact will have to be assessed.

The installation and commissioning of new detection systems for circuits RU.L4 and RU.R4 ('undulator') will be also pursued by QPS team, in conjunction with the upgrade of the corresponding current sensors performed by EE team.

In addition, the installation of a test system for the measurement of conical joints in the warm 13 kA circuits should be done in UA23; it requires the lock-out and grounding of the associated power converter.

Finally, all DQHDS will be switched off during the YETS in all sectors and the interlocks will have to be retested before powering.

MPE-EE

Concerning the energy extraction systems, a general and specific overhaul of the 32 installations of energy extraction in the LHC main dipole and quadrupole circuits will be done in all UAs (even points), RRs (13,17,53,57,73,7) and R34, R37; it requires the lock-out and grounding of the associated power converters.

MPE-ElQA

Among the activities of the ElQA team, the most important is the study of a possible relocation in point 6 of the current lead heater sources and the Proximity Equipment related to a possible displacement of the RQ5.L6 quadrupole; it should be transparent for recommissioning, since the check is part of the cryo-tuning activity.

Another important activity is the investigation of the earth fault on the circuit RCS.A78B2, with a type test to be done first (following the decision taken by LMC) and the final test to be discussed later.

ElQA will be then in charge of checking and re-making, if required, the signal transmission line from the DQLCT of B23.L7, heater #1.

But the most important part for ELQA will be the integrity verification at the end of YETS: depending on the temperature variations and the interventions on the circuits, more extensive tests will have to be done and the impact on re-commissioning will depend just on this list of ElQA tests.

Miscellanea

For PIC, no intervention is foreseen during the YETS, so no special recommissioning is required.

EN/EL will perform a visual inspection on warm bus-bars all around the machine to avoid surprises when restarting.

Finally, the RQ4.L/R1 modification, in the frame of the ALFA project (with the addition of one more water cooled cable per RQ on Q4 circuit around point 1), will require a short-circuit test plus a 24h heat run during the YETS; a complete re-commissioning of the 2 circuit during powering will be also needed.

More than 7000 tests will have to be performed in less than two weeks on the LHC superconducting circuits.

Warm magnets

A series of interventions will be done on the warm magnets, which will have no impact but is given only for completeness.

- RMSI Point 2 and 8 [EIS]
    - Installation of a new Control Crate for a better reliability and an optimisation of the spare card management (Analog Card will become Standard)
    - Rework at the level of the EIS for a better diagnostics
    - 1 day of test per converter: mise-hors-chaine will be needed
    - No intervention on power part
- RD34.LR7 [EIS]
    - Change of a DIVISOR MODULE card to solve a voltage measurement issue
    - 1 day of test: mise-hors-chaine will be needed
    - No intervention on power part
- RD34.LR3 [EIS]
    - Change of the ACTUACTOR board
    - ½ day of test: mise-hors-chaine will be needed
    - No intervention on power part
- LHCB Dipole
    - RPTI.SR8.RBLWH.R8 - installation of a new Control Crate to solve the issue of PC PERMIT bad contacts; tests to be foreseen
    - RBXWSH.R8 - partial DC cable replacement (EN/EL) ; 1 day for test (EN/EL)
- Exchange of some coil retainers in point 3 and possibly point 7 during the YETS on all the MQW magnets
    - Verification by powering the circuits (ramp up and down)
    - No cable disconnection no polarity check needed

ORGANIZATION

From March 4, the machine will be closed (excluding urgent, spot interventions) and the powering tests will be executed all around the clock. Concerning the team availability

OP – 3x8h
MP3 – 3x8h
EPC – 2x8h (7:00-23:00) + 1 shift on call
PIC – 1 extended shift

Tunnel accesses (exclusively related to powering) will be during the normal working hours.

MACHINE CHECK-OUT IN A NUTSHELL

The objective of the machine check-out (which will take place at the end of the powering tests) are multiple:

- check all equipment control functionality
- check the synchronization
- check the beam instrumentation acquisition chain
- drive all relevant systems, in a synchronized way, through the standard operational sequence
- check the functionality of the control system from the control room high level applications
- check machine protection and interlock systems
- during this phase many machine protection test without beam are accomplished

Ultimately, all systems have to be declared operational and the final task of the machine check-out is to test the readiness of the LHC to inject and accelerate a low intensity beam.

The beam cannot be injected and circulate without closing the BIS loop, which means that all clients need to be connected to the loop, in particular the LBDS; the LHC access key has to be on beam mode and all LHC vacuum valves have to be open. The hardware commissioning must be finished, with all circuits ON and without faults. Finally, there must be no interlock from non-maskable clients.

In particular, for the LBDS, the different functionalities have to be checked: the BETS, the XPOC, the synchronization between LBDS and RF; full check-out tests have to be performed with the system fully connected, in particular the energy tracking tests up to 6.5 TeV, the arming of the system connected to BIS once beam permits are OK, the circulate and dump sequence and a series of machine protection tests with the loop closed.

A list of relevant systems tests is given, which is only exemplificative and far from being exhaustive.

Vacuum

All sectors valves will have to be operational and interlocks will be tested by VSC and OP for both ring and experiments.

Collimators

Hardware and FESA should be tested with systematic ramps. Also machine protection tests will be done to check position, energy and beta-star interlocks. The injection protection tests will be done to check the interlock chain.

For the collimators with BPMs there are no special tests foreseen before beam, however a simulator to optimize the BLM alignment is available, and could be tested during 3-4 hours without beam with as many collimators, to move them in parallel.

LBDS

During YETS, the replacement of the TSDS ELMA crates will be done (redundant power supplies monitoring), which will require the full revalidation of the system needed during cold checkout. The visual inspection of the MKD/MKB generators will also demand for the revalidation by short reliability run in local at the end of the YETS; the same will be done for the replacement of 2/3 GTO switches (bad switch ratio).

Other important tests will be the full recalibration at the end of the YETS, the intensive checks following the general software maintenance and the verification during the UPS tests at the end of the YETS.

For the TCDQ, a verification of the calibration will be done.

Kickers

The numerous interventions on the kickers are given below and will be tested before machine closure:

MKI

- Upgrade thyratron heating system
- Implement fast vacuum acquisition of MKI interconnects
- Surveillance low voltage power supply in timing system
- Replacement fine delay V850 module by SVEC-FD module
- General software maintenance

MKQAc

- Upgrade from RIO3/LynxOS to MEN-A20/SLC6
- Verification HV contacts in AC-Dipole generators
- General software maintenance

Beam instrumentation

All interventions on the beam instrumentation systems will have to be revalidated.

BLM

- Test of the successful transition of USER_PERMIT [T->F] (5'x8 sectors) and the signal arrival at the BIC
- Test the change of the threshold values according to the beam energy signal received (1h); sectors 45, 56, 67 and 78 ramped to 6.5 TeV or in a simulation energy ramp (timing system fully operational)
- Check of the correct detection and propagation to the SIS for requesting a beam dump due to missing HV power supply on the system's detectors (1h)

BPM

- Will do BPM Fibre connectivity tests and software checks as much as they can to validate the new FESA3 server (BPMD class and BPMLHC class)
- Intensive check of FW and SW: Calibration, logging process, Post-Mortem buffers

WS (mostly qualified with beam)

- Check of the movements
- Check of the FESA class
- Check of the new functionalities of the FESA class

Standard checks on the BTV images/movements, the verification that the applications get data and the sequences work.

RF

RF will require 4 weeks for conditioning and commissioning. In this period, they will do some major controls validation on the new FESA3 software with some conditioned cavities before proceeding with full LLRF setting-up. No big activity is foreseen for the LLRF, just the usual 2 weeks (without beam) to complete the setting-up of the loops after cavities are conditioned (the setting-up of RF synchro and capture is then done in the background of machine setting-up).

Additional time is then requested for conditioning the klystron with higher cathode current. In fact, at present, the power is sufficient because the voltage is reduced to 10 MV in physics. We used 12 MV during run 1 (and the LHC design assumed 16 MV). If, for any reason, we have to increase the voltage above 12 MV, the 250 kW saturation will not be sufficient and we will need the design 300 kW.

CONCLUSION

The boundary conditions for the YETS are well defined; however few critical activities could have an impact and more than 7000 tests will have to be done in 12 days.

As usual, the good coordination between PT and machine check-out will be fundamental for a smooth transition to the operational mode. A lot of tests and verifications will be done and all the systems will be finally connected together.

All experts are already working on their systems to get ready for beam; machine check-out coordination will kick in starting from mid-February.

Ways can be studied to reduce the time for commissioning, but this has to be done without forgetting the priorities (Safety-Quality-Planning), since the rigorosity of the process is the key for a successful and safe operation of the machine throughout the year.

ACKNOWLEDGMENT

The author would like to acknowledge the many kind inputs by several people, in particular M. Bernardini, V. Montabonnet, H. Thiesen, R. Denz, B. Salvachua, G. Valentino, E. Carlier, E. Bravin, T. Lefevre, E. Piselli, C. Zamantzas, B. Puccio, J-C Garnier.