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First LHC Shutdown: Coordination and Schedule Issues

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Abstract

The first LHC shutdown started in fall 2008, just after the incident on the 19th of September 2008. In addition to the typical work of a shutdown, a large number of interventions, related to the "consolidation after the incident" were performed in the LHC loop. Moreover the amount of work increased during the shutdown, following the recommendations and conclusions of the different working groups in charge of the safety of the personnel and of the machine. This paper will give an overview of the work performed, the organization of the coordination, emphasizing the new safety risks (electrical and cryogenic), and how the interventions were implemented in order to ensure both the safety of personnel and a minimized time window.

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BASELINE SHUTDOWN BEFORE INCIDENT

Regular shutdowns are needed to maintain and/or inspect the different systems. The estimated minimum length of a normal shutdown was 18 weeks, i.e. 4 months, and was mainly driven by the helium inventory [1]: Performing the full maintenance of a cryogenic plant and associated cooling towers, induces the Liquid Helium emptying of the two adjacent sectors, out of eight. In 2009, the storage capacity of Liquid Helium at CERN was equivalent to two sectors. This meant that 2 sectors can be maintained at a time, resulting in this total duration of 18 weeks. Additional storage tanks have been ordered to get rid of this constraint, and decrease the length of future shutdowns.

During these stops, consolidation, upgrade and maintenance of other machine equipment, such as kickers, Radio Frequency, beam instrumentation, access... are also performed, according to mid and long term plans.

EXCHANGE OF MAGNETS: LOGISTIC ISSSUES

The incident of sector 34, on September 2008, affected around 50 main magnets, and polluted around 1 km of the beam vacuum pipes. After a safety campaign [2], and after disconnection, the damaged magnets were transported to surface for their repair or exchange. Due to their size, cryo-dipoles can only be lowered through one shaft in the whole 27 km long tunnel. With respect to the established safety rules, i.e., no heavy transport close to cryogenic lines under pressure and full of Liquid Helium, this implied emptying Liquid Helium from the two sectors which were crossed during transport, and therefore filled our storage capacity [3].

In order to check the status of interconnections in the other sectors, and understand the causes of the incident, splice resistance measurements, concerning the potentially faulty bus-bar interconnects were performed in the rest of the machine, which resulted in the need to replace/repair on the surface a few more magnets from three other sectors, and therefore to warm-up to room temperature these sectors, and empty the crossed sectors. Discussions with Helium providers started very early, in order to negotiate the repurchase and resale of Liquid Helium, which could not be stored on site.

Moreover, the logistics of transporting the cryo-magnets all around the machine was tricky, because one had to take into consideration the transport restrictions: no Liquid Helium presence in crossed sectors and the availability of repaired magnets.

OTHER ACTIVITIES AND LHE PRESENCE: THE CASE OF COLLIMATION

The normal shutdown foresaw other consolidation and upgrade activities like the installation of 20 collimators in the warm-part of the machine.

As an example, figure 1 shows the transverse cross section at point 7, where the collimators were due to be installed. Despite the fact that point 7 is a warm region, the presence of the Helium Ring Line (always under pressure for this particular shutdown) running all around the machine was a constraint.

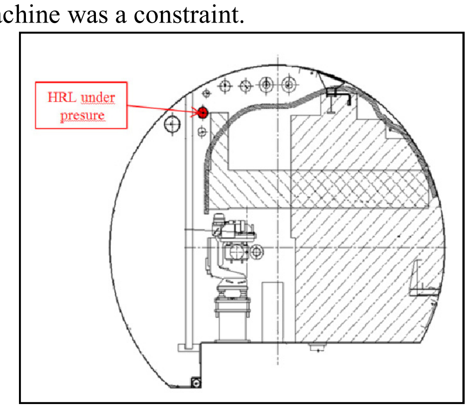


Figure 1: transverse cross section at point 7 – Helium Ring Line under pressure

With respect to the configuration of the machine, and the fragility of some equipment, all the works and logistics around cryomagnets or cryogenic lines has been studied carefully in order to ensure the safety of the intervening personnel [3].

This study of the safety aspects of working in a cryogenic environment was foreseen to be carried out in fall 2008, before the start of the annual shutdown. The early forced start obliged us to anticipate the study, and gather all the stakeholders during a busy period to get procedures for safe logistics. Nevertheless, all the cases were studied, and compensatory measures were put in place.

SAFETY TASK FORCE: ADDITIONAL WORKS

In January 2009, a dedicated Task Force on Safety of Personnel in the LHC underground areas following the incident of September 2008 was set up.

Based on the Most Critical Incident (MCI), the task force made a series of recommendation [4][5] which resulted in a huge amount of necessary works:

- The Experimental areas and the machine areas were sealed from each other in order to protect experimental areas, in case of an accidental Helium release, from Oxygen Deficiency, and guarantee the overpressure between the caverns and the tunnel [6].
- The anchoring of the Short Straight Sections with vacuum barriers was reinforced in order to avoid floor and fixation damages in case of a high pressure build-up inside the cryostat insulation vacuum [7].
- The ventilation doors of the machine areas were modified in order to create pressure relief devices and guide the overpressure flux in case of MCI [8].
- The Quench Protection System was improved, in order to enhance the diagnostic and protection capabilities significantly and provide a powerful tool for identifying potentially dangerous problems in the LHC superconducting circuits [9].
- The cryostat overpressure protection was modified (additional relief valves) to limit the maximum pressure in the insulation envelope [10].

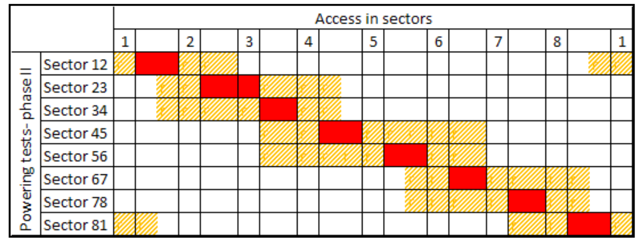
All these additional works impacted the schedule. Indeed deep studies were needed, as well as resources to perform these studies and the works. Thanks to the help of the experiments, who provided additional resources, the impact on the end date was limited. One has to mention also the positive effect of the economic crisis: For once resources from external contracts were fully available to consolidate our machine!!

HARDWARE COMMISSIONING

The recommendation of the Safety Task Force regarding the powering tests resulted in dividing these tests in 2 phases:

- First phase: powering up to 1kA, for which the probability for massive incidental helium release shall be negligible
- Second phase: powering above 1kA, for which the probability is higher, and for which an access matrix has been defined [11]. Table 1 summarized the access restrictions. For instance during the powering tests- phase II in sector 56, the access was not possible in sectors 34, 45, 56, and 67, which is the half of the machine.

Table 1: Access restriction for powering phase II in each sector



Such restrictions were very cumbersome. Additional time was needed to perform the preparatory work and shifts were organized to perform these tests overnight, outside the periods scheduled for work in other sectors. In addition the tunnel had to be patrolled and closed from the start of the second phase powering tests.

These additional difficulties on organization inevitably had an impact on the schedule.

EVOLUTION OF THE SCHEDULE

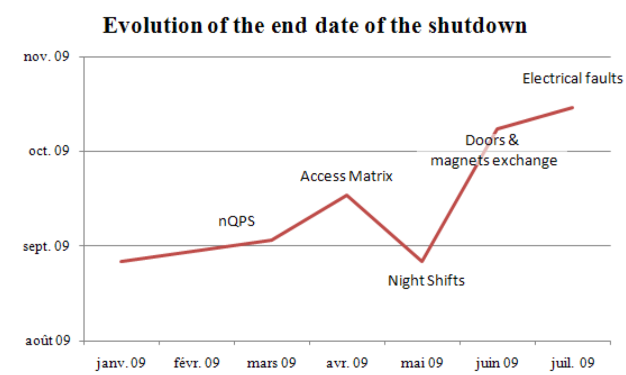


Figure 2: Evolution of the end of Hardware (re)Commissioning

CONCLUSION

The first shutdown of the LHC started at an unexpected date. The incident which occurred on the 19th of September 2008 implied a huge amount of work, which was again amplified by the various task force recommendations. The coordination and schedule were modified many times and continuously readjusted in order to minimise the time before restarting the machine. One year after the incident, thanks to a strong mobilization of CERN community and the great collaboration with external laboratories, the LHC restarted successfully and has now reached the particle collisions at 7TeV.

REFERENCES

[1] M. Batz, K. Foraz, Alternative scenarios for the current shutdown – Chamonix workshop 2009

[2] F. Bertinelli, Reinstallation and interconnections, LHC Performance Workshop - Chamonix 2009

[3] J. Coupard, S. Claudet, B. Delille, K. Foraz, "Work safety rules in LHC according to cryogenic conditions", EDMS no.1014325

[4] CERN-ATS-2009-002: "Task Force Report, Safety of Personnel in LHC underground areas following the accident of 19th September 2008"

[5] CERN-ATS-2009-003: "Report of the External Advisory Committee with respect to the report of the Task Force on Safety of Personnel in LHC underground areas following the sector 3-4 accident of 19 September 2008"

[6] S. Evrard; D. Mladenov; R. Vuillermet; O. Beltramello; D. Macina , "Modification TAS absorber in IR1", EDMS no.1011702

[7] O. Capatina, Improved anchoring of SSS with vacuum barrier to avoid displacement, LHC Performance Workshop - Chamonix 2009

[8] I. Ruehl, "Modifications to the doors in the LHC tunnel and service areas to control the air and helium flow in case of a large helium discharge", EDMS no.1001513

[9] R. Denz, QPS Upgrade and Re-commissioning, LHC Performance Workshop - Chamonix 2009

[10] V. Parma, Insulation vacuum and beam vacuum overpressure release, LHC Performance Workshop - Chamonix 2009

[11] LHC-OP-OSP-0016 rev 2.2 Access restrictions in LHC and SPS during LHC powering Phase II