# WHERE ARE WE WITH THE CURRENT SHUTDOWN?

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*Abstract*

Many conference series have adopted the same The first shutdown of the LHC machine started on the 17th of November 2008. In addition to typical shut-down interventions and the works already foreseen (e.g. phase 1 collimator installation), some additional consolidation work is needed. On top of this, comes the work caused by the 19th September incident and the subsequent tests carried out in November and December. This talk will give an overview of the activities currently planned and the key drivers for overall length of the shutdown, highlighting the critical points.

## INTRODUCTION

The start of the shut-down 2008-2009 was abruptly advanced (from January to November), after the incident of the 19th September. In addition to the maintenance activities, a number of consolidation and repair items have been identified during the powering tests and the following the incident. This paper gives an overview of the schedule, of its key drivers, the different activities to be performed and the critical points.

## KEY DRIVERS

The main key drivers of this special shut-down are:

- The repair activities of sector 34
- The helium storage capacity

plus:

- The safety restrictions with respect to cryogenic systems,
- The cryogenic cycle for a sector, which is not warmed up to room temperature

### *Repair activities of sector 34*

The end date of the shut-down 2008-2009 is given by the repair activities of sector 34, mainly the preparation of magnets on surface [1], their transport and interconnections underground [2]. All these activities, including the vacuum leak tests will be finished by the 19th June.

In addition to sector 34, it has been decided to warm up to room temperature three other sectors:

- Sector 56, in order to consolidate the three connection cryostats and the He level guards in the arc SSS (already done in all the other sectors at the end of installation)
- Sectors 12 and 67 where suspicious one suspicious high resistance magnet was found in each sector during additional powering & calorimetric tests after the 19th September.

### *Helium storage*

The current helium storage capacity, taking into account the existing storage at CERN, and the virtual storage (external storage via contracts) allow us to store up to 6 sectors of helium (the 6th one was emptied in mid-February). This means that the last two sectors can only be emptied, when the other sectors are ready to be cooled-down and re-filled with LHe.

### *Safety restrictions with respect to cryogenics conditions*

With respect to the configuration of the machine, and the fragility of some mechanical parts, all the work and transport around the cryomagnets/cryogenics lines has been studied carefully in order to ensure the safety of the intervening personnel.

Figures 1 and 2 below, show the lines under pressure with gas or liquid helium. The risk analysis performed, taking into account the quantity of fluid, and the pressure, showed that:

- During first warm-up or cool-down (between 80K and 300K), the access in the sector is closed;
- When cryogenics lines are full with Liquid Helium, no work and no heavy transport (i.e. cryo-magnets transport) next to these lines (except at very low speed, for light material) can be performed;
- During partial cool-down (without Liquid Helium) or QRL warm-up, no work around these lines can be performed;
- While when cryogenics lines are full of static helium gas, work and heavy transport can be done in the vicinity.

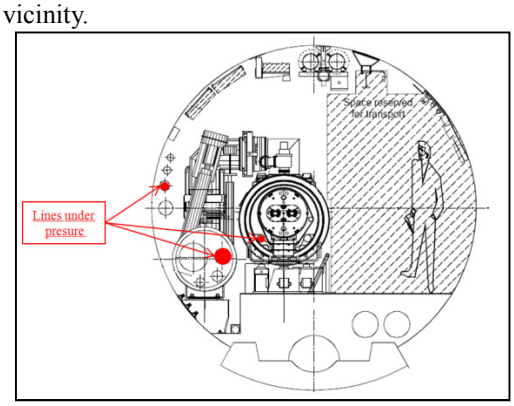


Figure 1: Transverse cross section – Lines under pressure during partial cool-down (Helium gas)

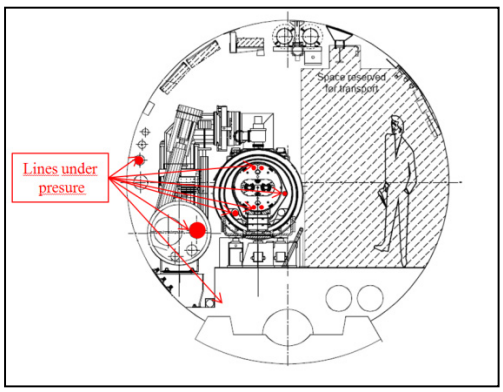


Figure 2: Transverse cross section – Lines under pressure at 1.9K (liquid Helium)

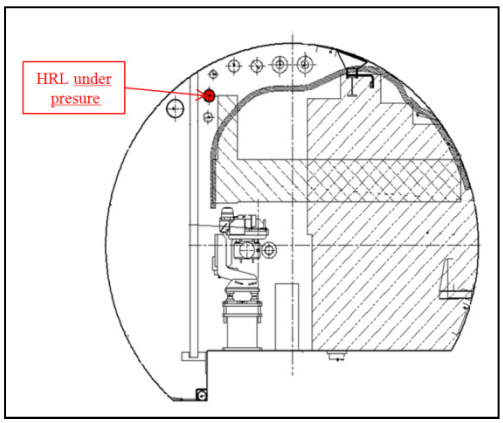


Figure 3: transverse cross section at point 7 – Helium Ring Line under pressure

In the particular case of Long Straight Sections 3 and , the existing configuration of the LHC cryogenics, forces us to send the helium from point 18 via the helium ring line. So cryogenics at point 18 has to be in operation for underground Liquid Helium transfer, and the helium ring line is considered under pressure and filled with Liquid Helium during the shut-down period. The configuration at point 3 and 7 is shown below (figure 3), and protections have to be put in place, either on collimators systems or on the Helium ring line, to meet safety requirements.

### *The cryogenics cycle for sectors which are not warmed up to room temperature*

With respect to the problem related to Plug In modules [3], floating sectors (i.e. sectors not warmed up to room temperature, but empty of Liquid Helium) have to be cooled down to 20K each four weeks (partial cool-down, which takes 2 weeks).

Moreover the warm-up of the cryogenic line (QRL), in order to consolidate the stand alone (see &xx), add an additional week of work restriction if QRL has already been warmed up to room temperature. If not the access in the sector is closed.

To summarize, the activities around the cryogenic lines (which are the longest) in floating sectors can only be performed during 3 weeks over a 6 weeks cycle.

### *Backbone of the shut-down schedule*

Taking into account all these aspects, figure 4 shows the backbone of the schedule.

For sectors warmed up to room temperature, the start of the cool-down is given by the end of the activities, and the end of dipole transport within the sector.

For sectors partially warmed up (i.e. sectors 23, 45, 78 and 81), the start of the cool-down also is given by the end of dipole transport and the end of activities in the sector, but taking into account the number of intermediate cool down cycles needed. The emptying of sectors 78 and 81 (to start work in those sectors) can occur only when the first two sectors (i.e. sectors 23 and 45) are being cooled and filled with Liquid Helium.

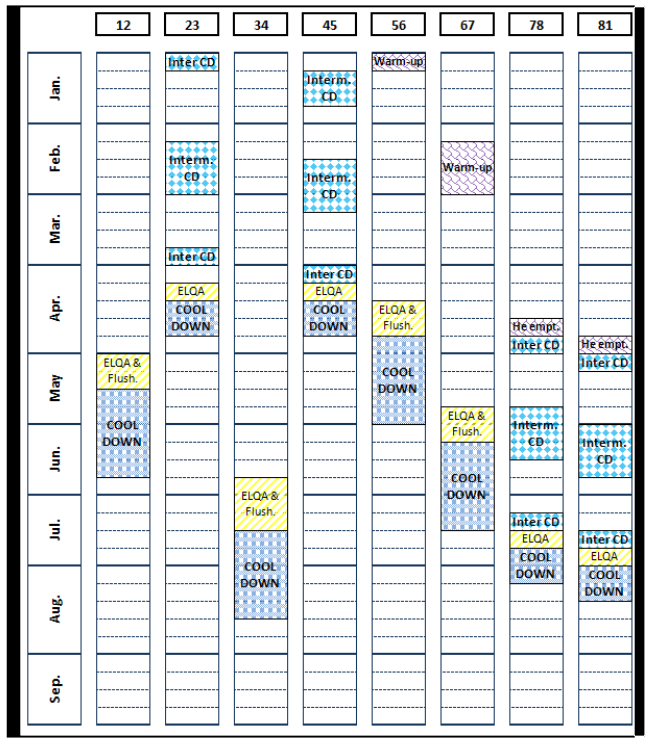


Figure 4: Back bone of the schedule

## MAINTENANCE ACTIVITIES

Maintenance activities should have been the core activities of the shut-down [4]. The maintenance work which drives the schedule are:

- Those which have a direct impact on the cryogenic conditions (no Liquid Helium in sectors): maintenance of the cryogenic plants, and the cooling towers.
- The electrical maintenance of the 400kV sub-station in partnership with EDF
- All the other maintenances don't impact the schedule, as they are in the shadow of the main maintenance and/or other activities: instrumentation inspection, mechanical inspection, check of electronics systems, access systems, security alarms, ventilation, handling systems...

## PRIORITIES

The Activities are prioritized according to operation at 5TeV beam energy, Safety, and the ALARA (As Low As Reasonably Achievable) radiation principle. Three priorities for interventions have been defined:

- Priority 1 = all activities must be performed during this shut-down
- Priority 2 = If not performed during this current shutdown, they must be taken into account for the second shutdown
- Priority 3 = All priorities 3 not performed during this current shutdown will be done during future shutdowns.

The target is to complete all priority 1 items, and carry out a maximum of prioritiy 2 and 3, especially for warm sectors.

## INSTALLATION, CONSOLIDATION AND REPAIRS

### *Service areas:*

The main activities in the services areas will occur in TZ76, where a modification of the underground layout is necessary in order to avoid radiation induced single event upset. [5] Other activities are scheduled, such as modification of piping in electrical alcoves RE (non conformities), or additional cabling in US.

### *Long Straight Sections – Warm part*

We can split the activities into two parts:

- Those on the beam line, which consist of
  - the completion of the machine installation, with the installation of 20 collimators (priorities 1 and 2), 4 new dump kickers on the dump lines, 4 roman pots around ATLAS, 12 detectors (TOTEM) around CMS, 4 beam monitors, the repairs of both TDI, the consolidation of the inox cages of the collimators, the replacement of 3 kickers, the consolidation of the Schottky monitor at point 4. These (re)-installation activities involve 40 vacuum sub-sectors to be opened, closed and baked-out again. Moreover, this work and especially the transport and handling must be scheduled according to the safety restrictions linked to cryogenics conditions.
  - All the elements are being re-surveyed, smoothed, and the vacuum chambers are being realigned.
  - The installation of remote handling system on top of the TAN in order to reduce the time of intervention in the future around these hot points.
- Those in the services areas, such as the installation of hoists in the RR caverns for power converters, the completion of shielding at point 7, and in the "fourreaux" of point 6 [5].

### *Long Straight Sections – Cold part*

The activities in the cold part of the long straight sections concern mainly consolidation work:

- The consolidations of Stand-alone: in order to reduce the cooling/tuning time of the stand alone, it is necessary to change the size of an internal capillary. Priorities have been set-up, with respect to the corrector types, and the indications given by cryogenic service.
- Additional cables are being pulled from surface to Q12, mainly for BLMs, to limit cross talk between detector ionization chambers and SEMs, and between the ionization chambers themselves for fast losses, but also for cryogenic systems, warm magnets…
- The Water Cooled Cables repairs: Due to the presence of chlorine in the reinforcement layer of the hoses, and the development of cracks on the hoses, it has been decided to start replacing the cables presenting non conformities. With respect with the deadlines, the total repair will have to be spread over more than one shut-down.
- The DFB consolidations including mechanical activities (protection of fragile parts of DFBs, Velan valves & instrumentation,
- The transfer of the actuors from UX85 to UL 84 for radiation purpose [5].
- The additional thermo switches on top of current leads in order to mitigate the risk associated with « software interlocks ».
- The Inner Triplet consolidation: Thermal strip & additional thermal sensors in IT1R & 5L

Most of the activities in the Long Straight Sections (both warm and cold), are not compatible one with one another, for safety reasons. Hence the schedule is very tight, and needs frequent complete revision when delays occur, taking into account the cryogenics conditions and the resources available.

### *Arcs*

In the arcs, the activities are split into two parts

- Those done in all sectors:
  - The annual magnet smoothing at cold including the preliminary measurements,
  - The installation of the new Quench detection system [6], including the cabling, connections, installation of racks and tests.
  - The modification of the relief valves of the SSS (Short Straight Section)
  - The reinforcement of the jacks for the SSS with vacuum barrier. [7]
- Those done only in warm (room temperature) sectors
  - The systematic change of Plug in Modules in the Dispersion Suppressor regions. In the arcs the PIMS are checked repaired as necessary.
  - The installation of relief valves on all dipoles cryostats[8]

- The magnet exchange and interconnections in sectors 12, 34 and 67
- The consolidation activities in sector 34 [2]
  - Powering tests

The powering tests have been scheduled according to the information given by the hardware commissioning team and a conservative approach concerning safety, where access are closed in the sector of powering tests and in the two adjacent sectors. New rules will be defined by Safety Commission by the end of March.

## CURRENT SCHEDULE AND CRITICAL POINTS

The sector 34 activities (both on the surface and underground) are on the critical path.

Coordination teams have also to pay attention to the magnet availability, especially for sectors 34 and 67, which will give the green light to start the cool-down sectors 23 and 45.

Activities that have not yet started, or where equipment is not yet at CERN, are also considered as critical, (e.g. the new relief valves on dipoles, the racks for the new quench Detection system, the springs of the SSS relief valves or the jack reinforcements).

As said before, the schedule of the Long Straight Sections is very tight, and the management and coordination teams have to pay close attention to the progress of the works.

## CONCLUSION

Figure 5 shows the shutdown schedule taking into consideration, the activities as defined by the CERN Management, the work, safety requirements and the access restrictions.

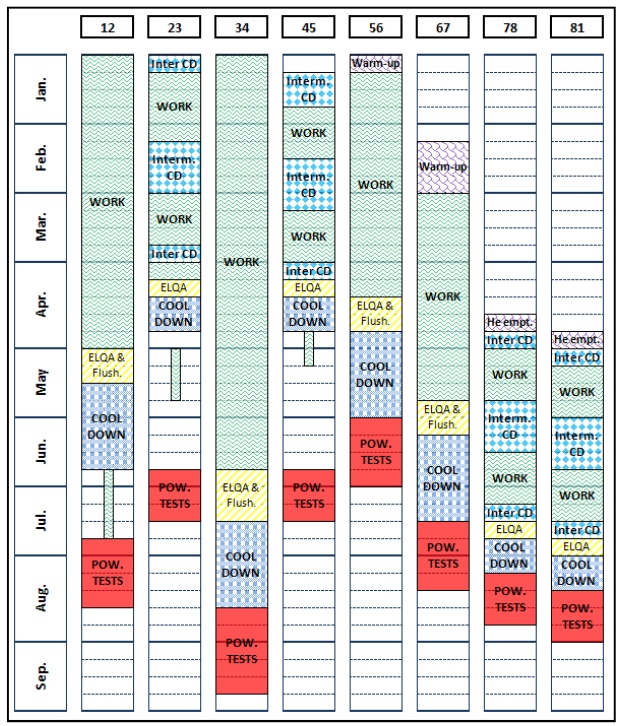


Figure 5: Current Schedule –Shutdown 0809

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