WHAT ARE THE REQUIRED MAINTENANCE AND CONSOLIDATION ACTIVITIES TO RUN AT DESIGN PERFORMANCE LEVELS (INJECTORS AND LHC) UNTIL 2035?

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Abstract

Assuming that Linac4 is connected to the PSB in LS2, we will outline the maintenance and basic consolidation works that will be needed to maintain design performance of the LHC and its Injector chain until 2035, with an overall reliability as good as that achieved in the first LHC operation period 2009 to 2013. Using these data we will estimate the shutdown schedule needed throughout this period to complete these maintenance and consolidation works. These estimates will also include the required radiation cool-down periods, time for system re-commissioning and testing as well as the time needed to restart the accelerator chain for LHC colliding beam operation. As some of the consolidation activities needed for the PS and SPS machines are related to the radiation dose taken by the machine equipment (e.g., irradiated cable replacement and magnet renovation) the variation of these time estimates as a function of beam losses in the Injector chain will also be covered.

INTRODUCTION

In order to compare the different upgrade scenarios, all over the accelerator complex, it is essential to set a solid frame, by establishing a baseline scenario, taking into account the optimum periodicity and length of Technical Stops, end of the year technical stops and Long Shut-downs.

The study presented includes only maintenance and consolidation needed to maintain 2012 performance and reliability levels, taking into account the resources availability as well as the cool-down periods with respect to the ALARA principle. It does not include the upgrade of PSB to 2Gev, the upgrade of the SPS RF system, or the HL-LHC program. The possible time-slots for the connection of Linac 4 to PSB are also presented.

TECHNICAL STOPS

Technical Stops are needed regularly in order to perform the minimum preventive and corrective maintenance. It is estimated that a Technical Stop of 5 days, each 10 weeks is needed to maintain good level of performance and reliability. .

END OF THE YEAR TECHNICAL STOPS (YETS)

In addition to the Technical Stops, a minimum time window of 10 weeks is needed in order to perform the legal and necessary annual maintenance of the different systems: cooling and ventilation, cryogenics, 400kVelectrical sub-station, kickers and beam dumping systems, access systems, RF, vacuum, beam instrumentation, power converters, safety systems... (The maintenance of the cooling and ventilation systems, as well as cryogenics installations are the time drivers).

In order to optimize this period, all the maintenance works preventing access to the underground infrastructures (i.e. test of the alarms, maintenance of the Jura sub-stations,…) will be done during the Christmas holidays.

The authors would like to emphasize the necessity of optimizing the cool-down period in the different facilities. This implies not to run with protons in the injectors and the LHC, for at least one month prior to the End of the Years Stops.

LONG SHUTDOWNS

After 3 years of operation in the LHC, each system needs to be stopped and be fully overhauled. The Long Shut-down program includes these recurrent activities as well as the necessary consolidation works.

"Recurrent" activities

In the LHC, the core of the "recurrent "activities are the maintenance of the different systems, and they will last a minimum of 16 months (beam to beam). The Cooling and Ventilation system as well as Cryogenic systems are again the time drivers, while all the other systems will be maintained in the shadow of these operations. These other activities include

- Septa and kickers systems maintenance, which will last 6 months (but will need a 6 months cool-down period with respect to ALARA principles),
- RF maintenance, which will last 6 months,
- Electrical systems, collimation, vacuum, beam instrumentation…
- Depending on the performance of cryo-magnets during beam operation, it is certain that a number of magnets will need to be exchanged. The current estimation is that some 20 magnets will need to be exchanges in each Long Shut-down. This will take 6 months (excluding warm-up and cool-down).

In the injectors, the 12 months needed for the maintenance of the cooling and ventilation system will drive the length of the "recurrent" activities. As in the LHC, the other maintenance activities will be performed in the shadow of these operations.

It is already foreseen to replace regularly the irradiated cables in the SPS, to clean-up the cable trays of unused cables, to renovate the SPS surface buildings (as included

in the CERN consolidation plan). A roadmap for the preventive maintenance of the injectors magnets has been set up: it includes exchange of SPS magnets and renovation of PS magnets.

Long shut-down 2 – LS2

In the LHC, in addition to the "recurrent" activities, compensatory measures are required for the MBW and MQW (installation of shielding and absorbers), and will cause significant work for the magnet group. In the injectors, in order to keep a good reliability level, the following consolidation works are needed on top of the "recurrent" activities:

- The connection of LINAC4 to the PS Booster - 9 months.
- The power converters of TT2 will arrive to their end of life. Their replacement will last 9 months.
- The SPS evacuation systems, the Beam Imminent Warning will have to be renewed– 1 year
- The fire detection cables, which are made of PVC will have to be exchanged – 1 year,
- The replacement of the SPS access system in order to be compliant with the rest of the chain.

Long-Shut-Down 3 (LS3)

In the LHC, assuming the forecast of integrated luminosity obtained by 2022, some equipment will have to be replaced:

- Inner Triplets at points 1 and 5 which will take 20 months (beam to beam)
- The pumping groups of the arcs which will take 6 months
- It is also likely that we will have to replace some of the collimators

It is also assumed that the cryogenic compressors, after 15 years of operation, will need replacing, but this will be transparent for the schedule as it will be done in the shadow of the cryogenic maintenance.

In the injectors, we only consider, for the time being to perform a full survey of the SPS, which is done systematically every 10 years.

Long-Shut-Downs program 4 & 5 (LS4 & LS5)

The current plan for LS4 includes the replacement of the Septa in the LHC (end of life), the continuation of the collimator replacement program, as well as the arc pumping replacement program, and potential replacement of a number of cryo-magnets. No additional activities are foreseen, in the injectors, except than the "recurrent" ones. The consolidation program of LS5, which will take place around 2035 is very hard to even guess, as it is linked to the integrated luminosity and the equipment performance. Nevertheless, we estimate a duration of 20 months for the LHC and 1 year for the injectors.

Overall plan – scenario 1

Scenario 1 includes the connection of LINAC to PS Booster during LS2, and the subsequent overall plan up to 2035. It should be remembered that scenario 1 includes no upgrade in the injectors or in the LHC. Scenario 1 is presented in figure 1.

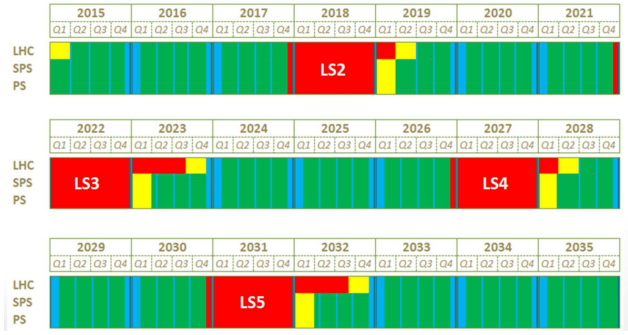

Figure 1: Scenario 1 up to 2035

This scenario results in a beam time fraction of 58% over the 21 years.

LINAC 4 CONNECTION TO PSB

A second scenario was studied with the connection of LINAC4 to PS Booster taking place during an additional Long Shut-down (LS1.5) in 2017. This scenario will push back the subsequent Long Shut-downs.

Figure 2: Scenario 2 up to 2035

This scenario is considered to have the following advantages

- Mitigation of the risk of LINAC2 failure before LS2
- LINAC4 is connected to the PSB immediately after commissioning in 2016 and is not left idle for 2 years.
- A reduction in the workload at the PSB during LS23
- A reduction in the workload of general infrastructure services, as part of the LS2 consolidation programs could be done during this LS1.5

On the other hand, a 9 months stop in the LHC is not sufficient to perform the full maintenance of the cryogenic systems, and will, thus not reduce the length of LS2. LS2 will have to start in 2019, to keep a good level of reliability. As a result, Scenario 2 reduces the potential physics output by one year, between 2015 and 2035.

CONCLUSIONS

2 baseline scenarios have been established, considering the essential maintenance and consolidation works, which are needed to maintain design performance of the LHC and its Injector chain until 2035. These scenarios are established a baselines to be compared with the various upgrade scenarios being considered at this workshop. It should be remembered that they will have to be updated, as decisions are taken concerning the upgrade programs, and the potential additional consolidation activities, which might be needed.

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