

# SUMMARY OF SESSIONS 2 & 3: SHUTDOWN 2012

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## Abstract

This paper summarises the two sessions, which were devoted to the activities planned for the next long LHC shutdown, which was originally planned to start in December 2011. The aim of the session was two-fold. Firstly to collect a reasonable idea of the major activities planned for the shutdown and secondly to highlight the potential impacts of delaying the shutdown by one year to 2013.

## OUTLINE OF THE SESSION

There were 16 presentations covering the following topics: Testing for 7TeV operation before the shutdown, Radio-protection issues in case of a delay of one year, Splice Consolidation - what do we have planned and how will we do it, Collimator installation, Other cryo-magnet activities, R2E, Work planned in the experiments, Vacuum, QPS, Cooling and Ventilation, Electrical services, Access and safety systems, RF Kickers and dumps.

## SESSION SUMMARY & CONCLUSIONS

The following questions will be tentatively answered: Which activities will drive the length of the shutdown? What could be a first estimate for the length of the shutdown? What are the critical activities which will be affected if we delay the shutdown from 2012 to 2013? The open issues highlighted during the sessions will also be addressed.

### *Critical activities, which drive the length of the shutdown*

The activities presented are divided into two categories; those which are essential to allow high intensity operation at a beam energy of 7TeV and those which are necessary to ensure reliable operation of the LHC for physics at 7TeV.

### *Activities to allow high intensity operation at 7TeV*

Since the energy of the beam is limited by the excess resistance in certain interconnections, the consolidation of the splices and the repair of cryo-magnets are essential to run at 7TeV. Moreover, the upgrade of the collimator systems (additional collimators in dispersion suppressor areas, and the upgrade of the existing phase 1 collimation system) will allow the machine to be operated at nominal beam intensity. In order to reach these nominal beam performances, the Radiation to Electronics (R2E) mitigation measures are also essential, in order to increase the Mean Time Between Failure for radiation induced failure in electronics installed underground.

The activities in the experiments should also be considered as vital for high intensity operation at 7TeV, as it is pointless to upgrade the machine without upgrading the experiments to fully exploit the improved LHC performance.

Finally, the plans to test LHC systems (except the main circuits) to 7TeV levels before the shutdown is very prudent as it would allow sufficient time for any repairs

### *Activities to ensure reliable operation of the LHC for physics*

In order to ensure reliable LHC operation we must ensure that all the machine services are in the best possible operating condition. These services are principally Cryogenics, Electricity Distribution and Cooling & Ventilation systems. These systems need regular maintenance, which has been reduced over the last three years to minimise the LHC shutdown time. It is vital to allow the sufficient time for a full maintenance of all these systems. On top of this, all the other machine systems will need full maintenance and in many cases improvements/upgrades are planned.

During the last two years a number of weaknesses have been identified in the LHC systems. Some, such as the QPS, have been or are being corrected and improved. Others, such as the UPS systems and the redundancy of cooling and ventilation systems for the LHC cryo-plants as well as the CCC computing facilities can only be completed during the long shutdown.

Table 1: Time estimates for individual activities

Splice consolidation work in tunnel	minimum 12 months
Cryo-magnet repairs	8 – 10 months
DS collimator installation	12 months
Complete Cryo-plant maintenance	14 months
R2E activities	15 months
Work in experimental caverns	15 months

### *How long should the shutdown be?*

Table 1 shows the time estimates taken from the longest activities. In order to accurately estimate the minimum length for the shutdown, we need not only to look at the length of each task, but also to consider the potential interference between the tasks and the underground logistics. This will mean that where activities cannot be executed in parallel, additional time and/or resources will be needed. The fact that the same expert resources will be needed for several different activities is also a bottleneck (see later section on Open Questions). One important

hypothesis taken into account is that the overall length for the shutdown is based on the “activities to allow high intensity operation at 7TeV”, while assuming that the activities to ensure reliable operation of the LHC” will fit inside this overall length.

The very approximate “plan” is shown in Figure 1 and this gives a first estimate for the shutdown length of 19 months. The length is defined as the period from “beam off” to “beam on”, including the time to warm-up and cool-down the sectors as well as a two month hardware re-commissioning period, but excluding the full beam

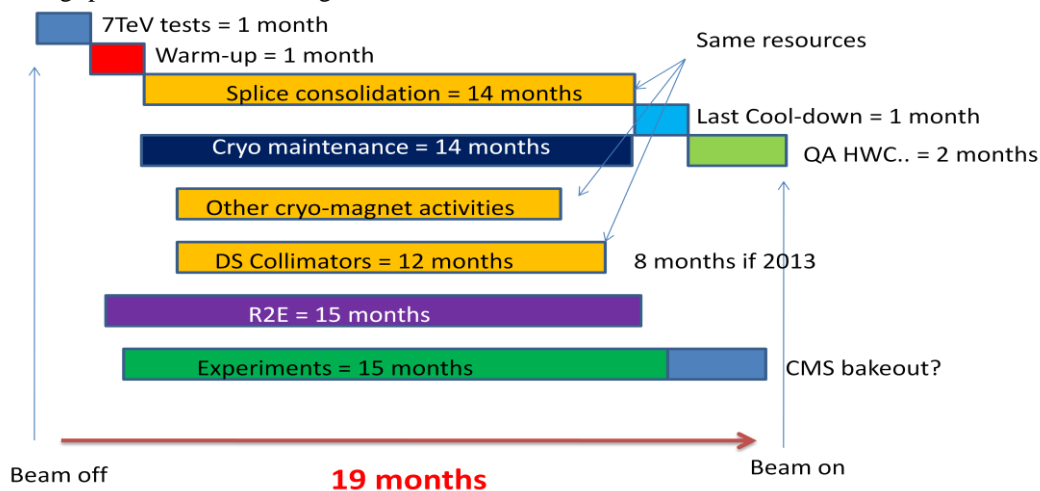


Figure 1: First estimate for the length of the shutdown, using the activities considered as critical. This does not include any real analysis of co-activity or any resource/manpower considerations

### 2012 or 2013?

The second question looked at during these sessions was what would be the consequences of delaying the shutdown from 2012 to 2013. Table 2 summarises these consequences.

There are a certain number of risks in delaying the shutdown, these risks concern mainly the maintenance of electrical, cooling and ventilation systems. There is also a question for the reliability of beam operation in 2012, if the R2E mitigation measures are not implemented. The question here is “Will the number of R2E induced failures expected disturb beam operation?” The answer to this question was not clear. Therefore it was not possible to really estimate the risk of continuing in 2012 from an R2E perspective. The answer seems to be “it should be just OK”.

There are a certain number of advantages to delaying the shutdown to 2013. The full DS collimator hardware will only be available at the end of 2012; therefore a shutdown in 2013 allows more time and flexibility for installation. Similarly the delayed shutdown would allow more time for system development prior to installation. This was considered as important by the kicker and the access system teams. The R2E mitigation measures would also benefit from a delayed shutdown if it is necessary to plan for major underground civil engineering to displace the safe-room at Point 7. It will not be possible to prepare

commissioning and set-up period. 19 months are considered as a minimum in view of the extensive amount of work planned.

It should be emphasised that the co-activity has been included in a very approximate manner (the time for the splice consolidation was increased from 12 to 14 months to fit with the time required for the full cryo-plant maintenance). Also the shortfall in specialised expert manpower has not yet been included. This will have to be done.

this work in time for a shutdown in 2012. Finally it should not be forgotten that the experiments will benefit from delayed shutdown, by, hopefully, making major new physics discoveries.

Table 2: 2012 or 2013?

Preference for 2012	Preference for 2013
Maintenance of services. No full maintenance done since January 2009.	DS Collimator installation Late availability of hardware
UPS reliability	Kicker and safety systems Additional development time
R2E: Will SEU perturb beam operation in 2012?	Experiments New Physics discoveries
	R2E: Civil engineering for safe room at point 7

### OPEN QUESTIONS

As stated previously, we have not included here the constraint of the limited amount of expert manpower available to do this work, and in particular the problem that this expert manpower will be needed for more than

one of the major tasks. As an example, the Splice consolidation, cryo-magnet repairs, and the modifications for the installation of the DS collimators all need to same expertise from TE/MS. Therefore they cannot be scheduled completely in parallel. This shortage of expert manpower will be a driving factor in the length of the shutdown. It is estimated that 200FTE will be needed for the underground work on the splice consolidation alone. Today only 2/3 of this manpower has been identified and even this assumes that there is no other work for these teams, which will certainly not be the case.

The same is true for the teams that look after the electrical systems and the cooling and ventilation services, where the expert supervision of external contractors will be needed in many areas in parallel. At the same time as all the maintenance and upgrade activities in the LHC, these teams will also have to work on the R2E equipment displacement, the upgrade of the electrical supply and cooling for both the CERN Computer Centre and the CCC computing facilities.

In addition it should not be forgotten that this long shutdown will also be the only opportunity to do major work on the LHC injectors. Such work could be important for the LHC Injector Upgrade project and for the overall Consolidation of the LHC Injector chain, but it will compete directly for the available resources with the work on the LHC itself.

A certain number of tasks were also mentioned, which it is not planned to do, due to lack of time and manpower. The most significant of these was the proposal not to replace the inverted beam screens in 12 Main Dipoles and 3 Short Straight Sections. These beam screens were installed after the incident of September 2008, as there were not sufficient spare beam screens of the correct type to insert in all the damaged magnets that were replaced. Including such tasks will almost certainly mean that the shutdown will take longer

## **SUMMARY**

Based on our present knowledge of activities, the minimal length of the next shutdown is estimated to 19 months to perform the activities to allow high intensity operation at 7TeV, and those to ensure reliable operation of the LHC for physics. The delay of the shutdown by one year will allow more time and flexibility for installation, as well as for development prior to installation. Moreover the experiments will benefit from a delayed shutdown, by, hopefully, making major new physics discoveries. The risks of a delayed shutdown are related to long period of operation for vital equipment (without full maintenance) and the risks associated with Radiation to Electronics. Some questions and issues are still open, especially the ones concerning resources. These two sessions are the start point of schedule and resource studies to be performed in 2011.

## **ACKNOWLEDGEMENTS**

The authors would like to thank all the speakers, who presented their information in a very clear and concise manner. These presentations stimulated a lot of interesting discussion during the workshop, and make an excellent basis for the schedule and resources study to be performed in 2011.