CONTROLS AND OPERATIONAL ASPECTS: GOING FROM COMMISSIONING TO OPERATIONAL REGIME

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INTRODUCTION

The session had as purpose to give a critical view on controls and operational aspects during the 26 days of successful beam commissioning at the end of 2009, as well as proposing solutions to the different problems. The following aspects were assessed. First the weak points of the LHC operation in terms of procedures, tools, discipline, equipment and organisation. A second contribution tried to address how to improve operational efficiency. The following two talks review the explicit problems of the accelerator control system and the RF system, respectivelly.

WHAT ARE THE WEAK POINTS OF OPERATION?

The short period of LHC operation in 2009 without and with beam revealed a number of weaknesses which could impact on machine efficiency, or potentially on machine protection. This contribution describes some of the weaknesses, grouped rather arbitrarily into Preparedness, Injection, Experiment-machine interface, Sequencer, Ergonomics, Discipline, System specifics, Procedural and General. Those weaknesses which are judged to have a potential machine protection impact are highlighted with the potential implications. The paper compiles a list of specific examples which will be of great use to be able to follow them up, as well as some possible solutions, as the basis for a discussion rather than as final solutions.

The contribution emphasizes that it is very important that Machine Protection should not passively follow the progress; it should dictate the progress, or at the very least limit progress at strategic points in the commissioning program. Operation of the LHC in 2010 above the safe beam limit will require much more discipline than in 2009, and Machine Protection should be central to the commissioning strategy.

HOW TO IMPROVE OPERATIONAL EFFICIENCY?

This paper quantizes in which points the operational efficiency was low such we have a criterion to establish priorities, and how to improve them. The data source has been the e-logbook from the 20th of November to 16th of December 2009 (the beam commissioning period). The notes in the e-logbook show that the machine was available for beam 60% of the time. The other 40% accounts for different type of problems which are described in the paper and which can be fixed for the next start up to recover between a 40 to 50% of down time. Those problems are cryogenics, pre-cycle and pre-cycle side effects, QPS specific issues and experiments issues. The other category of problems are believed to be part of the commissioning phase and were solved in due time.

The contribution explains that out of the 60% of machine availability half of the time at least one of the beams was present and beam commissioning could be performed. The other half of the time was devoted to preparation for injection; understand the dump via the analysis of the post-mortem data; and solve problems (most of them mentioned in *What are the weak points of operation?* by B. Goddard, in this proceedings). Most of the problems are being addressed and will be fixed for the next start up. But there are other problems that require a careful thinking, mainly the ones which solution has to be in place before unsafe beam operation. Those require a major debate.

Taking into account all the problems, the presence of any of the beams in the machine during the 26 days of beam operation in 2009 is 30% which is a very good result for a first start up of such a complex machine like LHC.

CONTROLS ISSUES: CMW SUBSCRIPTION, RBAC SET-UP

This presentation covered explicit accelerator control issues that we faced during the 2009 beam commissioning and outlines applied and planned actions needed to solve them before the start up in 2010. Despite the controls system was tested in different dry runs and injection tests, the real beam operation is the only moment during which the systems are fully stressed and problems which cannot be spotted during dry runs appear.

The following list of problems was covered with the respective solutions:

- Infrastructure (disk space and consoles): there was a massive increase of the total amount of controls operational data, from 400 GB in 2005 to 4 Tb in 2009. We are reaching the physical limits of the CCR in any sense. The controls group is analyzing a long-term solution which should be put in place by February 2010 based on new storage technology form HP. On the other hand the high load on consoles has been already fixed and works.
- CMW (Controls Middle Ware) proxies and subscriptions: under high load the Proxy doesn't respond promptly to a calling client which blocks the interaction with the front-ends or data sources. Several actions have been performed and validation of the new implementation is taking place during the dry runs of January 2010.

- Front-end instabilities: the problem has been trace back to an existing bug in FESA which has been fixed already and validated with RF equipment which was one of the most affected front-ends.
- Data publishing via Java Messaging Service (JMS): overloaded brokers stopped publishing data affecting page 1 publications, BLM and logging amongst others. In order to alleviate the situation the Controls broker has been moved to a new 16 core machine, and the Public broker stayed in the old machine. Other long term options are under analysis.

The contribution covered as well the policy for RBAC STRICT mode for the start up in 2010 and the new policy for controls release of software.

RF PERFORMANCE AND OPERATIONAL ISSUES

During the 2009 LHC run, a number of difficulties were encountered in the operation of the RF system and transverse damper.

In 2008/9, for operational simplicity, it was decided to use a fixed cavity quality factor of Q_{ext} = 60000 at injection and top energy. At injection, with 1 MV per cavity, this requires only 45 kW of RF power. In a klystron, the residual DC power not consumed as RF output power is dissipated in the collector and with the low RF power required in this operational configuration, the collector power was close to the rated maximum. Traces of overheating were indeed observed when several klystrons were checked in January 2010. In order to reduce the collector power, it was decided in 2009 to run with fewer cavities, with higher voltage per cavity. Eventually a configuration was found which was more or less reliable using 5 cavities at 1.6 MV per cavity. Another measure to reduce collector heating was to modify the front-end software to automatically switch the power system to the READY state when the RF was switched off.

The choices for 2010 were presented and the most preferable one is using the movable coupler to change the Q_{ext} after injection which is the only long-term solution for higher intensities, and is the choice strongly preferred by the RF group. The drawback is that more commissioning time is needed. Some serious operational problems were encountered with front-end software for the power system, and these have now been solved.

Various causes for synchronisation problems have been understood and resolved.

In order to be ready for unsafe beam, a number of interlocks will be added for the total RF voltage, RF frequency and the revolution frequency synchronisation.

A number of developments are still outstanding in the Low Level RF, including the 1-turn feedback, longitudinal feedback and longitudinal emittance blow-up.

Commissioning of the ADT system with beam has started, and will need dedicated time in 2010. The noise spectrum needs particular attention. Some hardware changes will be done before the 2010 start up, but performance for multi-bunch operation will need to be checked due to residual ripple from the cables.

Abort gap cleaning has been shown to be promising, but further optimization of the pulse shape will be required.

CONTROLS AND OPERATIONAL ASPECTS: GOING FROM COMMISSIONING TO OPERATIONAL REGIME - DISCUSSION

Chair : Reyes Alemany and Verena Kain – Scientific secretary : Delphine Jacquet
Palais des lumières, Evian, France

WHAT ARE THE WEAK POINTS OF OPERATION? (B.GODDARD)

B.Goddard's presentation explained that despite the general agreement that the 3 weeks of LHC operation were a success, some weak points have been revealed and should be addressed. The weaknesses were encountered in several operation aspects like equipment, tools, procedure, discipline and organisation. The discussion that followed the presentation is summarized next:

- Concerning the point that there was no clear definition of what needed to be achieved before to move to the next commissioning step, S.Meyers commented that the definitions were established, but as everything has been done in a rush, it hasn't been formally followed.
- For the over-injection problem, Giulia Papotti said that in case of beam with too low intensity, the SPS beam quality monitor (BQM) inhibited the SPS extraction, so low intensity beam should not be a cause of over-injection.
- In the presentation, it is explained that TIM communication glitches causes the interlock on powering/access status to switch OFF all the LHC power supplies by mistake. L.Ponce corrected that the source of the problem was not TIM but the JMS broker that is in the communication chain with the equipment. The latter was down because too many subscriptions were requested for the BLM system.
- In his presentation B.Goddard expressed a need to get an overview of all the collimator statuses. Ralph Assman commented that such a display wouldn't be useful to detect any problem, but one should rely on interlocks and alarms that will clearly point out any problem with collimator position. On the same subject, Alick McPherson said that the alarm system is a good indication of problems but the safety is only provided by the interlock systems. Markus Albert also stressed that the operation team should take the good habit to look more often at the alarm screen.
- During his talk, B.Goddard expressed his concern on the LHC safety. He said that nothing was really preventing operation to inject high intensity beam in the LHC, and too much unsafe operations were allowed. Mike Lamont answered that only low intensity beam was supposed to be injected, and nothing dangerous has indeed been performed during the 3 weeks of operation. The potential for mistake will never be reduced to null, and one has to rely on a good coordination team that gives clear instructions to operation, and the operation team has to be trusted to follow them. He also reminded that there was a request to progress very fast, which was an acceptable requirement as only safe beam was injected. Then he pointed that everybody was learning from scratch to operate the LHC so the weakness showed were completely normal, and should nevertheless be addressed.
- Concerning operation in general, Walter Venturini pointed out that the procedures are not always up-to-date, so one should be more careful to have them correct to avoid mistake. Also Alick McPherson would like to have a better overview of all the LHC individual systems.

HOW TO IMPROVE OPERATIONAL EFFICIENCY? (R.ALEMANY)

Reyes Alemany's talk gave some statistics on the 3 weeks of beam operation. She showed the beam availability ratio and explained the major causes of down time. Then she gave potential solutions for the biggest problems, and showed how the operational efficiency could be improved. The presentation was followed by a discussion reported as follow:

- The idea of restricting the access to the equipment to the sequencer only, the latter running only by the EIC from the EIC console was discussed: RBAC would be used, a super user created that would be the only one allowed. It was pointed out there are 2 persons on shift, so what is the use of the operator if he's not permitted to do anything?
- Ralph Asmann expressed his concern on the sequencer reliability. He said that if the sequencer does the wrong request to the equipment or load the wrong setting, it would not be detected because the equipment won't give any interlock as it is doing what requested. He wonders if this is safe enough for a run at 3.5GeV. Mike Lamont said that the sequencer is not a safety system, and safety is

always ensured by the machine protection system.

- Markus Albert said that for safety and efficiency, the key point is a good discipline and team work in the CCC. The EIC should always keep track of what is done by all the persons present in the LHC island.

RF-PERFORMANCE AND OPERAIONAL ISSUES (A.BUTTERWORTH)

A.Butterworth gave a presentation that described the operational difficulties encountered during the 3 weeks of operation and the solutions that have been, or will be, put in place. Then he explained which part of the RF system is now ready for higher intensity and which is still to be done. Finally he said a few work on the readiness of the damper system for next start-up.

- One of the major problems RF faced during last run was the klystron collector that was damaged because it received to much power. The question of the problem criticality was raised. Andy Butterworth said that this problem has to be seriously addressed as there are only few spare collectors.
- The damper system detected a ripple in the cable response from pick-ups. This is under investigation, W.Hoffle said that the biggest noise is understood, but still a part of the ripple is unexplained.
- It was asked why there is no interlock when the RF is OFF for a cavity. A.Butterworth answered that it's possible to run with some cavities OFF, so the interlock should better be on the sum of all cavity voltage.
- O.Brunning asked if some instrumentation is available to check that the beam is in the right bucket. A.Butterworth answered that the mountain range application can be used for that.
- About the Schottky monitor, it was said that it would be available for the start-up.
- Ralph Asmann pointed out that the machine impedance could quickly become an issue, so the transverse dampers have to be commissioned soon.