PSB AND PS CONSOLIDATION FOR LS2 AND BEYOND

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Abstract

The consolidation activities proposed for the PSB and PS until the end of LS2 will be revised. Particular attention is given to the activities with direct impact on machine operation and machine performances. The analysis on the interventions and priorities proposed will be done by system (e.g. injection, extraction, RF, beam instrumentation, etc..), with the goal of verifying that the consolidation activities of a specific item is consistently taken into account by the different groups.

INTRODUCTION

The consolidation activities proposed for the PSB and PS are revised with the goal of verifying that the consolidation activities of specific items are consistently taken into account by the different groups and considering activities with direct impact on machine operation and machine performances.

Activities are categorized according to the following families:

- Activities Not Approved but needed to operate the machine effectively (NA).
- Activities Approved and Needed to operate the machine effectively (AN).
- Activities Approved or Not Approved but Not Urgent to operate effectively the machine (NU).
- Activity in LIU because PICS and/or upgrade (PICS= PERFORMANCE IMPROVING CONSOLIDATION) (LIU).

The analysis was done on the different activities considering only the ones impacting directly on PS-PSB operation and machine performances. As example, the asbestos removal from buildings or cooling pipes is considered as an important intervention but without a direct impact on machine performances. The same for the AUG (Systèmes d'arrêts d'urgence généraux), which are fundamental in case of an accident requiring a prompt cut of the electrical network, but have no impact on machine operation (if properly maintained). Both topics are not subject of this work.

Concerning the general infrastructure, even if it might look like less impacting the daily operations, one has to consider that if there are no good cables or good cranes, keeping the machine running with high reliability can become an issue. Still, this will not be a subject of a detailed analysis.

Last but not least, consolidation activities related to radioprotection (RP) are not included because are not part of the accelerator consolidation project, but profit from a dedicated one.

The paper is based on the information provided by the different equipment groups and presented in the different IEFC meetings (see BIBLIOGRAPHY section).

PSB INJECTION

H^- injection operational after LS2 (LIU)

The PSB injection will be completely rebuilt during LS2 to allow for the connection of the Linac4. The main elements related to the 50 MeV proton injection are going to be replaced by the ones of the 160 MeV H^- injection.

Injection line magnets to be consolidated (AN)

The consolidation of the LT-LTB(-BI) that will remain in operation even during the L4 era has been approved.

PS INJECTION CONSOLIDATION

New injection elements for 2 GeV operation (LIU)

The main injection elements of the PS currently in use for the 1.4 GeV operation (septum and bumpers plus their power converters) are not compatible with the future 2 GeV operation and they are going to be replaced during LS2. Until then, the usual maintenance will be sufficient to maintain the current machine reliability.

KFA45 tank (AN)

The vacuum tank of the injection kicker is considered as a single point of failure, with no spare available in case of need for an urgent replacement. The construction of a spare has been approved and should be ready by LS2.

PSB LATTICE SYSTEMS

As "lattice systems" are intended all the magnetic ring elements used during the accelerating cycle.

Spare coils for multipole stacks (AN)

Multipoles, up to skew octupoles, are heavily present in the PSB lattice since its construction. In total there are 112 units currently installed. They were originally conceived for chromaticity control and resonance compensation. The approved proposal foresees the production of 2 spare units for each of the 4 families currently not covered by spares, for a total of 8 new units.

Cooling circuit main magnets (LIU)

The cooling circuit of the main magnets is going to be renovated in view of the 2 GeV operation planned after LS2.

Spare coils for main bends (AN)

Spare coils for the main bends will be made available in view of the 2 GeV operation, requiring larger magnetic field and thus larger currents, which is more demanding for the 40 years old coils.

PS LATTICE SYSTEMS

As for the PSB, the "lattice systems" identify all the magnetic ring elements used during the accelerating cycle.

Main magnet units renovation (NA)

In the last few years since 2005, ~55 main magnet units were renovated by replacing the main coils and the pole-face windings by newly produced ones. The renovated units were chosen on the basis of the radiation damage and the risk of breakdown due to bad insulation.

It is proposed to partially renovate all the remaining ~45 units during LS2 by replacing only the pole-face windings for which signs of degradation of the insulation have been observed. In fact, in case of multiple magnet failures during a run, there is a certain risk of long down time since only one magnet unit per magnet type is available.

The intervention implies the removal of the ~45 magnets from the tunnel and the dismantling of their vacuum chambers. The replacement of the chamber enameled flanges, consumed by the repeated opening of the vacuum during the last decades, could be carried out during the same period.

Considering the fact that this intervention would consist of the removal of more than 45% of the machine elements, a staged approach could be considered.

Magnets/power converters for low energy correctors (LIU)

Some of the existing correctors used at low energy are no longer compatible with the future 2 GeV operation. For this reason, the vertical and the skew correctors are going to be replaced. The low energy quadrupole magnets and the back-leg windings will remain un-touched.

All the power converters of the correctors are going to be replaced by new ones with increased maximum current before LS2.

PSB RF SYSTEMS

Replacement of C02, C04 systems (LIU)

The C02 and C04 RF systems, both based on ferrite loaded cavities, should be replaced by a single broad-band system based on the Finemet© technology. After a first series of tests, a degradation of the final amplifiers once exposed for a long time to a significant amount of radiation was observed. The final decision on the new system installation will be taken in 2016. In case it would not be possible to install the new Finemet© system, the C02 and C04 are going to be consolidated such that they will also be compatible with the future LIU beam parameters.

C16 renovation (AN)

The C16 RF system will be renovated.

A modern interlock and control interface (AN)

The old G64 interface is going to be replaced by a more modern one.

PS RF SYSTEMS

10 MHz power system (LIU)

The power amplifiers of the 10 MHz main accelerating cavities are going to be renovated by LS2 to cope with the future LIU intensities.

In the same framework, a new gap relay development is ongoing, since a unique company produces the existing gap relays and CERN is the only customer for this device.

40/80 MHz power converters (AN)

The existing power converters of the 40 and 80 MHz cavities used for the production of the LHC-type beams are now reaching their end of life. The Inverpower 150 kVA power converters are showing a reduced reliability and are clearly limiting the 40 MHz system performances. The new power converters will be able to deliver up to three times more current than the existing ones.

A modern interlock and control interface (AN)

The old interlock system and its G64 interface is going to be replaced by a more modern one. This also to avoid a failure of one of the 40 MHz cavities, due to an undetected malfunctioning of the cooling system.

PSB EXTRACTION

Extraction and recombination kickers and septa (LIU)

The renovation of the extraction and recombination kickers and septa is part of LIU in view of the 2 GeV future operation.

Switch magnet BT-BTP (BT.BHZ10) (LIU)

The magnet BT.BHZ10 directs the beam extracted from the PSB either to the PS via the BTP line or to the external PSB dump or ISOLDE via the BTM line. The magnet is going to be replaced in view of the future 2 GeV operation.

PS EXTRACTION

Spare KFA71-79 modules (AN)

The extraction kicker KFA71 is composed of 12 independent modules located respectively, 9 in straight section (SS) 71 and 3 in SS79. Spare modules are going

to be built, since the production of the LHC beams depends on the availability of the kicker.

New oil circuits, as for the other kickers of the CPS complex, are going to be installed.

Additional spare magnetic SMH16 + 57 (AN)

The magnetic septum located in SS16 is used to deliver the beams to the SPS whereas the magnetic septum in SS57 is used for the slow extracted beams towards the EAST Area. Both need new spares for potential replacements of the operational ones.

BEAM DIAGNOSTICS SYSTEM

Wire scanners (LIU)

A new generation of wire scanners should replace the existing ones by the end of LS2. The activity is part of the LIU project.

TV Beam Observation System (BTV) (NA)

The BTV system is considered fundamental for the daily operation of the CPS complex. There are also lines like the ones of the EAST Area where the beam can be steered and brought to the experimental zones exclusively by using the BTVs. Currently the electronics, the cameras and control systems for video distributions need consolidation that was not approved. This is should be considered a high priority task.

PSB beam loss monitors and fast PS/PSB loss monitors (LIU)

The PSB ACEM beam loss monitors in the ring are going to be replaced by LHC-type ionization chambers. Additional ionization chamber beam loss monitors with a flat geometry more adapted to the tight space available between the different PSB rings will be added to increase the coverage. Moreover LHC-type beam loss monitors will replace the ACEMs installed in all the PSB injection and transfer lines.

A series of diamond-type detectors are going to be installed in the PS and PSB to monitor fast losses in specific locations, like the injection and the extraction regions.

PS beam loss monitors (NU)

The PS ACEM beam loss monitors, as for the PSB case, could be replaced by LHC-type ionization chambers, in view of having a common technology in all the injector complex, but also to eradicate the now 30 years old ACEM detectors. The number of available spares is decreasing and the calibration procedure is not compliant with the ALARA ('As Low As Reasonably Achievable') principle. For the moment, only the budget to renovate the acquisition electronics is secured.

PROTECTION SYSTEMS AND DEVICES

WIC – Warm Magnet Interlock Controller (NU)

Almost all the machines of the LHC injector complex are protected by a dedicated WIC, whose role is for example to protect the warm magnets from overheating. The only exceptions are the transfer lines between the PSB and the PS, the PS ring and TT2. Whereas the existing interlock system might be maintained, a new WIC would be more meaningful with respect to the rest of CERN. LS2 would also probably be the best moment to implement the new WIC, considering that during LS2 a big cabling campaign will take place and about 75% of the WIC implementation constitutes cabling activities.

BIS – Beam Interlock System (NU)

The BIS is used to protect the accelerators to inhibit beam operation if a subsystem indicates that it is not ready for safe beam production. Whereas it is clearly a necessary system for the LHC, the SPS and the future operation of the PSB with the Linac4, the necessity of a BIS in the PS is less clear. In any case, a future BIS in the PS should be considered as a new project, and not part of the consolidation, since there are no similar systems currently implemented.

Beam stoppers (NA)

The current situation of the numerous beam stoppers of the PSB and PS could not be evaluated yet, so there is no clear consolidation request yet.

BEAM DUMPS

PSB external beam dumps (AN)

The PSB external dump was renovated during LS2 due to its ageing, but also to be compatible with the future 2 GeV operation.

PS internal beam dumps (LIU)

The PS internal beam dumps are not any longer adequate for a safe operation with the existing LHC-type beams in case of a failure of the cooling system and their use is not possible with the future LIU-type beams.

A new design of the internal dumps is progressing within the LIU project, together with the consolidation of their control system.

VACUUM SYSTEMS

PSB vacuum systems (NU)

The vacuum of the PSB is considered of very good quality, and the PSB is going to produce, also in the future, exclusively protons. For this reason, the replacement of the TMP (turbo molecular pumps) and the old ion pump groups is not considered a high priority. The two activities are considered important, but in view of the optimization of limited resources less urgent than other interventions.

PS vacuum systems (NA)

The success of the ion run in the PS is also the result of the high vacuum quality maintained during the years. For this reason, the consolidation of vacuum pumps, gauges and valves and TMP pumping groups should continue without any loss of continuity. An additional argument for renovation is also the evidence of corrosion found on some of the vacuum systems that might degrade significantly the vacuum and thus the beam quality during future ion runs.

CV ACTIVITIES

PSB

For the Cooling and Ventilation of the PSB there are two main activities, which are considered as high priority to secure beam operation, but that were not approved for consolidation:

- *Replacement of the ventilation system (NA).*
- *Refurbishment of the demineralized water-cooling plant (NA).*

PS

Considering the PS activities, two main interventions will take place by the end of LS2, i.e.:

- *Conclude works started in 2000 on the chilled water pipes (removal of asbestos) (AN).*
- *Consolidation of the Cooling stations (AN).*

Two other activities, instead, which have a direct impact on the machine operation have not been approved yet, i.e.:

- *Consolidation of the PS central building cooling station (RF building) (NA)*
- *Consolidation of the warm water network in the PS area (NA).*

POWER SYSTEM

Electrical distribution (NA)

A new SVC (Static Var Compensator) is needed with a new sub-station ME59, and requested for LS2.

Main power converters

The PS is currently running on the new POPS (Power for the PS) capacitor-based main power converter. After the identification of some degradation of the capacitor banks, their status and an eventual replacement is still under investigation.

During a recent campaign of high-voltage tests for the PS main unit bus bars, it was found that there are no spare parts for the machine-to-power generator bus bars. *Their procurement is considered a high-priority task (NA).*

The existing PSB main power converter is not going to be consolidated since a new one, based on the same POPS technology, will be built by LS2 to allow operation at 2 GeV (LIU).

Auxiliary power converters

About 20% of the auxiliary power converters of the PSB and the PS are planned to be renovated (AN).

The BT.BHZ10 will receive a new power converter compatible with 2 GeV operation (LIU). The details of the interaction with the access system for enhanced safety (2 power converters) are still under discussion.

A new generation of high precision current digital control loop has been already deployed in the PSB and for some PS equipments. *This FGC (Function Generator Controller) based control* should be deployed almost everywhere by the end of LS2 *(NA).*

CIVIL ENGINEERING

The civil engineering interventions related to consolidation could not be defined in detail, since depending on cabling, CV and other group activities, which are also not sufficiently well defined yet to determine now the priorities, except for:

- *Work for chilled water upgrade of PS/PSB to be concluded during LS2 (AN).*
- *The work related to the cable campaigns (clean-up or installations), whose details are not yet defined (NA).*
- *Flushing of PS tunnel drains (AN).* This activity should not be underestimated, since in 2014 the PS had to stop for nearly 1 day because of a water leak in the EAST zone that could not be properly evacuated due to dirty drains.

GENERAL CONTROL SYSTEM

OASIS - Open Analogue Signal Information System (AN)

The OASIS system provides to the CCC the acquisition and display of analogue signals of the different machine equipments and it is an indispensable tool for machine monitoring during daily operation.
OASIS is a VXI-based system with multiplexers and a triggering system that must be maintained operational and consolidated on a regular basis.

Operational databases upgrade (NA)

The consolidation of the operational database includes the upgrade of the disk controllers, servers and network switches. In particular, the IT maintenance policy requires the replacement of the hardware no longer covered by warranty. By definition, the operation of the machines needs a consolidated operational database, storing all the machine settings for the different physics users.

CompactPCI FECs (NU)

The consolidation of the Intel Single board computers (CPU boards) used for the local front-ends is required because after 2017 it could be impossible to install new LINUX operating systems for OASIS, RF and ABT systems and thus could introduce IT security issues.

PLS-SU receivers (NA)

The PLS receivers, about 100 in the entire complex, are local electronic boards generating a specific cycle timing for selected users. These receivers are located for example in the local control rooms or in the equipment rooms.

Their unavailability can significantly hamper the diagnostics possibilities, for example for the RF/BI experts, and their replacement is considered pretty urgent.

TTL-Blocking converters (NA)

The timing pulse distribution in the injector complex is mostly done using Blocking logic levels (24V), for a total of 400 TTL-Blocking systems, designed and manufactured in the 1980's, which now are becoming obsolete. A new system, already proposed, can offer remote monitoring and failure detection. The replacement of the converters is considered a high priority.

Septa and kicker controls

The septa and kicker controls are outdated with respect to more modern systems used elsewhere in the LHC and the injector complex. A harmonization of the system is planned by the end of LS2.

CABLES

PS kicker/septa cables

There is going to be *a renovation of new electrostatic septa HV cables (AN)*, which in many places are considered as consumable items due to the fast decay of the material properties induced by radiation.

The renovation of the 80 kV kicker HV cables (AN) is going to take place, partially in collaboration with LIU.

The PFL RG220 cables in B.359 (NU) are reaching their end-of-life, but their replacement is not considered an urgent activity.

Cable clean-up campaign (NA)

The PSB and PS complex is suffering from, now endemic, missing space for new cables due to the cumulative installation of new cables done in the past without a parallel clean-up of existing, obsolete, and un-used ones. A clean-up campaign should take place as soon as possible, in particular to allow the installation of new equipment foreseen for LS2, but also to assure the correct functioning of the existing devices. During LS1, a campaign to identify un-used cables was extensively carried out in the PSB and the PS, with the goal of removing the kilometres of unused cables between now and LS2.

Particularly crowded and thus critical regions have been identified:

- Bld. 360-361 (under the Booster), BCER, BOR, BAT
- Bld. 354, room CCR et MNR, gallery 815
- Gallery TP9 between Bld. 354 and Bld. 361
- Bld. 353 (ring center) and tunnel of PS Bld. 350.

TRANSPORT

The renovation of transport elements is necessary to assure fast and effective interventions during normal machine operation. Currently, the budget for the remaining main activities in the PSB and the PS, i.e. the crane *PS (B151) – PR3 (40t) and the PSB table (AN)* are both approved. Possibly interventions should be concluded before LS2, when important activities will take place in the PSB/PS.

ELECTRICAL NETWORKS

LV Distribution Network Consolidation (NA)

The obsolete elements of the Low Voltage distribution network must be replaced in many systems, but instead of proceeding for a 1-for-1 exchange, a more detailed analysis will be done with upgrade programs to identify the new and critical installations.

Consolidation Meyrin HT infrastructure

The consolidation of the HT infrastructure of Meyrin will not impact specifically on machine operation, with the only exception of a minor *PSB-related part already included in LIU (LIU).*

TT2

Power converter consolidation (AN)

The consolidation of the power converters of TT2 has been approved for LS2 and a functional specification document has already been approved in preparation of the power converter family design.

Magnet renovation (NA)

The magnets of TT2 clearly show signs of degradation due to their ageing and numerous cycles. In total, 36 more magnets, together with their cooling circuit, should be refurbished during LS2.

Beam loss monitors (NU)

As for the PS ring, the replacement of the ACEM monitors would bring more modern and maintainable detectors also in TT2.

CONCLUSIONS

The consolidation activities mentioned in the paper are of fundamental importance to keep high machine

availability and performance for the PSB, now more than 40 years old, and the PS, more than 50 years old.

The presented vision is from only one perspective, i.e. from the point of view of the activities proposed for consolidation that seem to impact directly on machine operation, and the presented list is most probably not exhaustive.

It is considered vital that consolidation activities with direct impact on injector upgrades will continue to be budgeted and executed according to LIU time lines. This is particular important for the PSB, as reported in EDMS 1082646 v.3 (see sec. 20.2.17).

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