MINUTES 7th EVIAN WORKSHOP - SESSION1: "OPERATIONS"

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INTRODUCTION

The operational performance of the LHC in 2016 was reviewed and compared with respect to the past years. Key aspects, limitations and improvements were analysed; further developments to push the machine performance beyond present achievements were proposed.

E. BRAVIN - "OPERATION OF A 6 BCHF COLLIDER: DO WE FIT THE EXPECTATIONS?"

LHC performance and luminosity reach in 2016 confirmed that all the systems, including operation, fulfilled the expectations. Further improvements can nevertheless be envisaged for what concerns tools, communication, written procedures and documentation. The main goals should be facilitate the integration of new comers, reduce the number of operational mistakes and fasten the diagnose of recurrent problems to minimise the turnaround time.

Discussion:

J. Wenninger commented that things quickly evolve in operations and keeping the procedures updated is not evident. He also asked what E. Bravin means with "intelligent" softwares as an example of improved tools.
E. Bravin replied that there are several well established procedures for activities which are regularly performed in operations but no documentation exists. Written guidelines should be available and would simplify the learning process of new EIC and operators, especially in view of the future turnaround of people. He then explained that an intelligent software is capable of performing some data analysis and can provide a guidance in the diagnose of a problem or a system fault reducing the investigation time (see also K. Fuchsberger's talk). For example, in case of unsuccessful injections, a tool that checks all the active interlocks (in the SPS, TL and LHC) and identifies the problem would drastically improve the operation efficiency. He added that all information is available but it has to be adequately organised. **J. Wenninger** asserted that written procedures are important but the EICs should maintain a level of knowledge which allows them to operate differently still insuring the safety of the machine. This is particularly important during MDs when unconventional activities are performed.
M. Lamont underlined that fiftytwo faults were imputed to operational mistakes in 2016 and asked if a 6 BCHF machine can afford that. **E. Bravin** answered that these faults mainly occurred during commissioning or MD time and they had only a very little impact on the physics production. He commented that this kind of mistakes can hardly be reduced. **M. Lamont** insisted that operation should aim to a failure rate as low as in the aerospace science environment.

W. BARTMANN - "LHC INJECTION"

During Run 1 injection losses were dominated by showers from the transfer lines while longitudinal losses gave the main contribution in Run 2. A clear improvement was observed in the transfer line stability after the reduction of the MSE current ripples and no limitation is expected for injections of up to 288 bunches. The longitudinal losses are strongly dependent on the beam configuration and could be reduced by one order of magnitude when using the second 40 MHz PS cavity. Batch spacing of 200 ns and 800 ns (MKP and MKI rise time) in the SPS and LHC respectively can be reached. Improvements are being implemented in the IQC (revised thresholds and color code) and diamond BLMs will be added. Automatic preparation of the LHC beam in the injectors is proposed

Discussion:

J. Wenninger reaffirmed that IQC thresholds should be more consistent with respect to BLM dump thresholds. They should unambiguously indicate when injections have to be stopped and the beam quality from the injectors or the transfer line steering have to be checked and improved.
R. Schmidt asked clarifications about the follow up of the diamonds installation, operation and also the control part.
W. Bartmann explained that the diamonds are under the full responsibility of BI people who have also to coordinate the different activities with the other involved teams (ABT, MPE and collimation). He explained that works are already on going to standardise the system and make the data available for operation and not only for experts. He added that diamonds are already used for online loss monitoring at the SPS extraction. **R. Jones** confirmed that the system will soon be like any other BI system.
V. Kain commented that an automated preparation of the beam in the injectors during the LHC ramp down should be possible and would indeed reduce the turnaround time. Still a non negligible effort is needed to put that in place for all the different machines and the OP manpower is principally busy with shift work. **D. Jacquet** underlined that an efficient communication between the different CCC islands is a key requirement to optimise the operational time. She also reminded that in 2016 the problem with the SPS dump prevented the preparation of the the high intensity beams far in advance. **B. Mikulec** added that the time for LHC beam setup should not cause a loss of physics for the other users.

K. FUCHSBERGER - "TURNAROUND: ANALYSIS AND POSSIBLE IMPROVEMENTS"

For the presented analysis, the turnaround was defined as the time between two consecutive "stable beam" declarations and faults inducing stops longer than 24 hours were discarded. The time needed to perform each operational step (e.g. end of "stable beam" to dump, ramp down, injection, ramp up, etc.) was carefully evaluated and the injection process was identified as the dominant contributor to turnaround. New diagnostics will be available after the EYETS that should allow a faster detection of the problems preventing successful injections into the LHC. A median turnaround time of 5.2 hours was estimated for 13-17 hours long fills. Stopping the precycle at 3.5 TeV instead of 6.5 TeV allowed to gain 21 hours, not further significant gain is expected.

Discussion:

J. Boyd asked what the difference in average turnaround time was between programmed and emergency dumps. **A. Apollonio** answered that the difference was of the order of 0.5 hours.
M. Lamont asked if removing every stop longer than 24 hours could have cut off important information. **A. Apollonio** and **L. Ponce** answered that this was of course an arbitrary choice but it allowed discarding exceptional events (e.g. weasel induced damages, cryo recovery and MKB failures) which would have faked the operational turnaround time evaluation.
B. Goddard asked if an analysis over the different years was done and if any change or improvement was visible. **D. Nisbet** answered that this was not done and it would require a considerable effort (one man month work). **M. Solfaroli** added that the data were not treated in the same way in the past so that a direct comparison is not possible.
L. Ponce reminded that many faults were transparent since they occurred and could be solved before the end of the ramp down. **K. Fuchsberger** confirmed that including those failures would have doubled the number of recorded faults. **M. Zerlauth** commented that several circuit trips happened during the ramp down and one should check if any optimisation is needed to avoid these failures.

D. NISBET - "CYCLE WITH BEAM: ANALYSIS AND IMPROVEMENTS"

The analysis was based only on proton physics fills which reached "stable beams". Performance in 2016 was excellent, the machine was extremely reproducible and improvements could be observed through the whole beam cycle. The most significant improvement was given by the use of the combined ramp and squeeze while the injection process was still the biggest limitation. Further gains can be envisaged, in particular at injection, but will generally tend to be less and less effective. Parallelisation and optimisation of some sequencer tasks could help in pushing the performance beyond the present achievements.

Discussion:

J. Wenninger commented that combined ramp and squeeze could be pushed toward 1 m β^* (now 3 m). Optimising the "adjust" phase is complicated because of the totem bump while the collision process in IP1 and IP5 could be revised.
W. Höfle asked why the mean and the average time at injection differed more than for the rest of the machine cycle. **D. Nisbet** D. Nisbet explained that the injection phase is where most unexpected events can occur, and also gave an example where in some cases the fill number was not updated if a dump occurred at injection and the fill had to be restarted (thus the fill time is much longer). **R. Tomas Garcia** asked if the change of the tune from injection to collision could be incorporated in the squeeze process to gain some time. **D. Nisbet** commented that this could be done however the gain is not significant (20 s of beam process, 3min if all settings overhead are included).

J. WENNINGER - "MACHINE REPRODUCIBILITY AND EVOLUTION OF KEY PARAMETERS"

LHC reproducibility in terms of tune, chromaticity, coupling, orbit and IP offsets was revised. The machine proved to be extremely reproducible, especially at top energy, with the only exception of the decay and snapback effects. Coupling could be improved by moving the tune change to the end of the squeeze as it was done for the ATS optics MDs. All these observations could endorse the option of limiting the number of test cycles when reusing a previously tested set of settings even after a long interruption. The triplets caused the largest orbit perturbation and affected mainly stable beams at low β^*. This behaviour became clearer in 2016, partially also for the more systematic usage of the WPS system. Common correctors in the OFB could improve the orbit control, provided the reproducibility of BPMs is adequate. Periodic fast orbit oscillations at the mm level were observed on the levelled luminosities and on DOROS BPMs but no explanation could be found.

Discussion:

G. Iadarola commented that the chromaticity is the only parameter which is not stored in any repository; having it available on TIMBER would simplify the data analysis and the correlation with other observables. **J. Wenninger** answered that chromaticity could be indeed logged in TIMBER anytime its value is modified.
J. Boyd asked if the shown reproducibility could allow to reduce the validation and setup time. **J. Wenniger** answered

that it should be possible to go faster to stable fills but main revalidation will still be needed.