SESSION 1: 2011 OPERATION

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Abstract

This document summarizes the talks and discussion that took place in session 1 concerning 2011 operation. A first talk ("Introduction and review of the year including OP issues", by M. Pojer) summarized the main phases of 2011 operation. The second talk addressed the "Premature dumps" (by M. Albert) identifying the main reasons that caused them during proton operation. The third talk ("The 2011 run: availability and statistics", by A. MacPherson) pointed out the main reasons for machine downtime. The last talk ("Turnaround: analysis and possible improvements", by W. Venturini Delsolaro) analysed when time was spent in the operational cycle and highlighted possible improvements.

2011 OPERATION

The success of 2011 is spelt out by the luminosity records that were achieved over the year:

- the target for the year of 1 fb^{-1} for the integrated luminosity at IP1 and IP5 was reached already in mid-June;
- the 1 fb^{-1} for LHCb was exceeded in mid-October;
- the peak luminosity at the high brightness experiments ATLAS and CMS reached $3.7 \times 10^{33}\text{cm}^{-2}\text{s}^{-1}$, i.e. one third of the design value despite having half the number of bunches, half the energy and twice the beta star.

The main phases of 2011 operation were recalled. The year started with a fast hardware recommissioning after the Christmas stop (only about 3 weeks). The recommissioning with beam was also very fast and followed by an initial intensity ramp-up with 75 ns spaced beams. A few days of physics with 1.38 TeV per beam were then followed by a scrubbing run. The scrubbing run allowed the continuation of operation with 50 ns beams, and the intensity ramp-up proceeded with 50 ns beams until the maximum of 1380 bunches/ring.

Once the maximum number of bunches per ring was reached, improvements in the peak luminosity were given by beam parameters (intensity and emittance) and squeeze factor. First, in the beginning of July, the beam scheme production at the injectors was changed from "single batch" to "double batch" (referring to the transfer from the PSB to the PS), which allows smaller transverse emittances per bunch. Initially the beams were transversely blown up at the SPS, this was then "adiabatically" stopped to fully profit from the small emittances produced at the injectors. Next, the β^* at IP1 and IP5 was reduced from 1.5 m to 1 m, so that another 50% in peak luminosity was gained as of the beginning of September. The intensity per bunch was then slowly increased, reaching up to 1.45×10^{11} ppb in one of the last proton physics fills of the year.

The achievements in operations in 2011 were made possible by the outstanding performance of all machine subsystems: e.g. power converters, RF, ADT, beam instrumentation, collimators, LDBS, injection systems, vacuum, magnets, magnet protection, cryogenics, technical infrastructure, etc. This resulted in a machine which is extremely reproducible and stable, and where a routine handling of 110 MJ beams resulted in no quench from stored beams yet.

A list of punctual problems and outstanding issues was also recalled, e.g. single event effects, UFOs, MKI erratics and flashover, cryogenics stops, etc.

PREMATURE DUMPS IN 2011

Data was analysed from the Post Mortem database and it was recalled that about 480 dumps were performed with more than 10^{12} p in the machine. Out of these, 36% happened during the machine mode "stable beams", and 37% while in "injection physics". Non-programmed dumps are a large fraction of those (375, or 78%): 45% happened during "stable beams" and 33% during "injection physics" (out of which $\approx$10% were related to injection problems). About two thirds of the non-programmed dumps were due to equipment failures, about one fifth was initiated by the shift crews, and much smaller fractions were triggered by a failure in one MPS system or by beam monitoring elements.

The main system failures to cause dumps were found to be: QPS system, cryogenics, power converters, RF, electrical network problems, feedback system tripping one circuit, vacuum, controls, collimators, etc. To be noted that the first 5 systems caused 77% of the dumps. Concerning dumps caused by beam monitoring, the main player is the BLM system triggering on beam losses. It was also noted that 22% of "stable beams" fills were dumped by SEU effects, mainly on cryogenics and QPS equipment.

AVAILABILITY AND STATISTICS

The 2011 luminosity production exceeded the brightest expectations, and a number of records were set. The total

time allocated to the proton run was about 160 days and 34% of that time was spent in "stable beams". The remaining time was split into ≈20% at injection, ≈20% with the machine in access and ≈20% in setting up in preparation for beam. Concerning the luminosity production period, a Hubner factor of 0.202 was derived. For the ion run, 28% of the time was spent in "stable beams", 25% in setting up the machine for beam and 22% in access; the Hubner factor was calculated to be 0.171. On average, the time spent at injection was about 1 and a half hours for both proton and lead physics fills.

A histogram of the faults as attributed in the elogbook was produced, pointing to the following main causes: cryogenics (≈530 hours), no beam from the injectors (≈310 hours), electrical problems (≈170 hours), QPS (≈140 hours), power converters, collimators, LBDS, etc. It was pointed out how the fault tracking, despite having slightly improved since 2010, is not yet a fair indicator for the reasons of downtime, as for example many faults were hidden in the shadow of others. This has to be tackled before the end of the 2011/12 Christmas stop.

During the discussion, B. Goddard added that the statistics from equipment groups could be also used to improve the tracking. J. Wenninger pointed out that a revision of the fault attribution beyond the shift would be useful and could be performed on a daily/weekly basis by the machine coordinators in charge for that period. W. Höfle asked whether the emittance ratio from beginning to end of fill was one for a majority of fills only because the fill duration was not taken into account in the calculation and A. MacPherson confirmed that.

TURNAROUND

Homogeneous sets of fills were looked back at and analysed to quantify the turnaround time, defined as the time elapsed between the declaration of the beam modes "dump" to "stable beams". Fills that reached "stable beams" with 1092 and 1380 bunches were analysed, for both β^* 1.5 and 1 m.

The shortest turnaround times were quoted: the achieved record was 2 hours and 7 minutes. To be noted that only for 6 fills the turnaround was shorter than 3 hours. The importance of a short turnaround was highlighted: short time at injection minimize the dependence on injector's availability and emittance blow up; some equipment is not needed during stable beams, so a faster turnaround minimizes the probability of an impact of possible failures.

A number of improvements were put in place since the 2010 run: the automatic decay corrections by FiDeL, the parallelism of the injections in the two rings, some improvements on the IQC, a faster ramp and squeeze, etc. Possible improvements for 2012 were listed:

- improvements for injection (guidelines for transfer line steering, updated reference trajectories, dedicated SPS supercycle for LHC filling);
- a possible start of the squeeze already during the energy ramp function (tested successfully without beam in 2011);
- alternative methods for correcting the b3 decay with the lattice sextupoles (in 2011, the ramp function was extended by 6 minutes, this could be shortened by e.g. joining the ramp and squeeze functions);
- a faster rampdown function: up to a dozen minutes could be gained by running the RQ4.R2 in open loop and tuning the dI/dt of the RQXs;
- the optimized rearrangement of tasks in the nominal sequence and the possibility to execute tasks in parallel; the incorporation and regeneration to be performed in the background of functions as ramp and squeeze.

During the discussion, R. Schmidt suggested to try the faster rampdown functions during the hardware recommissioning, W. Venturini Delsolaro agreed pointing out that the faster functions on the RQ4.R2 had been tried only a couple of times so far. B. Goddard asked about the improvements in the mode "injection probe", J. Wenninger pointed out the importance of the FiDeL automatic corrections and S. Redaelli highlighted the parallelism in the Injection Sequencer (new feature in 2011 with respect to 2010) which made the injection process less dependent on the IQC analysis time. V. Kain pointed out that very few minutes with probes are possible if few corrections are needed, while if e.g. the coupling is not acceptable, then some more time is needed given that the corrections are based on a trial and error technique. She added that switching between 3 cycles in the injectors is also a reason for delays. M. Albert added that the chromaticity measurement needs improvements as it cannot always be blindly trusted, resulting in longer measurement times. R. Steinhagen commented that the chromaticity measurement is tuned such to be compatible with the operation of the tune feedback; additionally, a faster modulation would not be acceptable for the QPS. S. Redaelli added that the possibility to measure the chromaticity during filling would be useful, M. Lamont wondered whether the very tight control of chromaticity is still critical after the finer tuning of the octupole currents. Y. Papaphilippou suggested alternative measurement methods, e.g. the tune from the BPMs or the chromaticity from the beam decoherence. G. Papotti stressed that the variability of the time spent in "adjust" depends mostly on whether the initial luminosity scans are performed before or after the declaration of "stable beams": indications from the experiments through LPC on the preferred procedure would improve the statistics and uniformity across shift crews. O. Brüning stressed the importance of having meaningful statistics for the turnaround time to be able to use it for projections on future performance or machine designs.